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INTERIM SITE CHARACTERIZATION
REPORT
FOR
SOUTH CAVALCADE STREET
HOUSTON, TEXAS

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

000967

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Work Assignment No.: 47-6L56
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1.0 INTRODUCTION

This Interim Site Characterization Report has been provided in accordance with Task 1, Subtask 1.1 of the January 18, 1985, Work Plan Memorandum prepared by CDM for the South Cavalcade Street Site. The purpose of this subtask is to provide a description of the current situation of the South Cavalcade Street Site in relation to the site's Hazardous Ranking System Score of 38.7 on the National Priority List (NPL). Data pertinent to the site and its contamination problem were gathered, organized, and reviewed.

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Major issues addressed in this report are as follows:

Site Background

Provides a summary of the regional location, pertinent area boundary features, existing ownership and use (subdivision of the property), and the general physiography, hydrology, and geology of the site, from secondary sources.

Nature and Extent of Problem

Summarizes the actual and potential onsite and off-site health and environmental effects that can be anticipated from pre-remedial investigation sources. This may include, but is not limited to, the types, physical characterization and amounts of any hazardous substances; and the potential pathways of exposure, contaminant release, and human exposure.

History and Response Actions

Describes any previous response or remedial actions conducted by either local, state, federal, or private parties, including site inspection, technical reports and their results.

2.0 BACKGROUND

2.1 SITE LOCATION AND HISTORY

The South Cavalcade Street Site is located within the incorporated boundaries of the City of Houston, Texas, the state's largest city and the fifth largest in the nation.

The site covers about 69 acres in northeast Houston, about one mile southwest of the intersection of Interstate Loop 610 North and U.S. Route 59 (Figure 2-1). The site is bounded on the north by Cavalcade Street, to the south by Collingsworth Street, on the west by the Houston Belt and Terminal (HB&T) Railroad Passenger Main and Maury Street, and on the east border by the HB&T Freight Main (now the Missouri and Pacific R.R.)

The National Lumber and Creosoting Company (NLCC) operated a wood treatment facility on the site from 1911 to 1939. An early aerial photo of the site (1933) indicates the actual wood processing/treatment facilities used by the NLCC were concentrated in the southern end of the site along Collingsworth Street, with wood storage yards occupying the remaining southern and central parts of the site and vacant (idle) lands in the northern third. A neighboring commercial development of about three acres, immediately across the Houston Belt and Terminal (HB&T) Railroad main to the west of the site, and also fronting on Collingsworth Street, shows on the 1933 photo as well. This property is identified at a later (and expanded acreage) stage as a Mobil Oil Company products distribution center (wholesale).

In 1940, the Koppers Company, Inc. (KCI) acquired the property from NLCC and operated a wood treating facility and coal tar distillation facility on the site from 1940 to 1961. Aerial photos of the site during the period of KCI operations (1944 and 1953) indicate only minor changes in site development or use from the 1933 photo. The 1953 aerial photograph shows an expansion of the Mobil Oil Company operations across the tracks west of the site to about 10 acres, including the addition of a tank battery and rail siding at the north end of the Mobil site approximately 1,000 feet north of

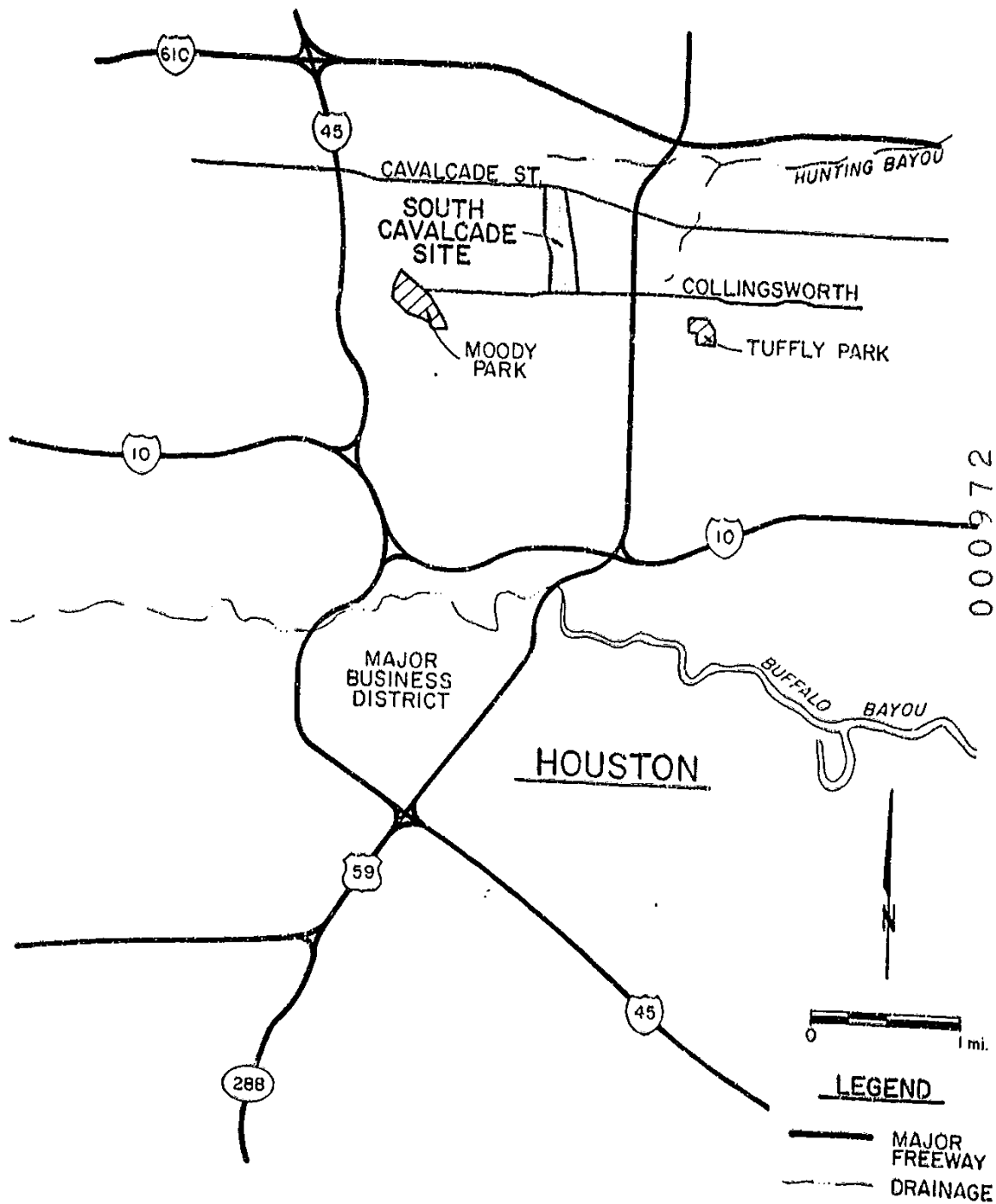


FIGURE 2-1
SITE LOCATION MAP

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Collingsworth Street. Also, by 1953 some commercial development had begun just to the north of the South Cavalcade Site. Although not confirmed through deed records, interviews with early Koppers Company personnel, previous owners and local residents indicate the probability of a smaller scale wood treatment operation just north of the present day Cavalcade Street in the early 1950's.

The KCI property south of the present day Cavalcade Street was transferred by recorded deed to Merchants Fast Motor Lines (Meridian Transport Company) in 1962. The property was subsequently subdivided into three ownership tracts, as shown previously on Figure 2-2. A northern portion of about 22.5 acres was transferred to the Baptist Foundation of Texas. This tract has been leased and developed by the Transcon Trucking Lines, with a sub-lease to AJF Leasing, Inc.

A central tract of about 18.2 acres remains in the ownership of the Meridian Transport Company and is presently undeveloped and idle. The southern tract of about 28.3 acres was subdivided into two tracts after its acquisition by Meridian Transport Company in 1962. The southeastern 13.4 acres is owned by Rex Reed and presently used by Palletized Trucking, Inc. The southwestern tract of 14.9 acres remains in the ownership of Meridian Transport Company and is developed for use of the Merchants Fast Motor Lines.

The Houston Metropolitan Transit Authority (MTA), as part of its proposed METRO Stage One Regional Rail System (RRS) study, investigated the feasibility of including the property designated in this report as the South Cavalcade Street Site as a yard, shop and terminal facility for the RRS. Under contract to the Houston Transit Consultants (HTC), prime contractor to the MTA, the firm McClelland Engineers, Inc. (MEI) was selected to perform a geotechnical investigation of the site. During the course of that investigation, observations were made of probable contamination of the site with toxic waste materials from previous commercial or industrial users.

At that time (early 1983) the state agency responsible for hazardous waste control, the Texas Department of Water Resources (TDWR), was notified of the probable contamination of the site. The TDWR then initiated the state's process of investigation to determine the nature and extent of the problem, the present and prior ownership and use of the site, and the possibility of voluntary compliance with remedial clean-up operations at the site.

At the same time, the Houston MTA, acting through HTC and its geotechnical consultant MEI, contracted with the environmental engineering and consulting firm Camp Dresser & McKee Inc. (CDM) to perform a comprehensive contaminant survey of the site. A CDM report entitled "Cavalcade Contaminant Survey" in three volumes, dated July 11, 1983, provided the first detailed assessment of the extent and nature of hazardous contamination at the Cavalcade Site.

In April, 1984, the TDWR recommended the site to the U.S. Environmental Protection Agency (EPA) for inclusion on the National Priority List (NPL) of hazardous waste sites. On October 2, 1984, the South Cavalcade Site was placed on the NPL, with EPA taking the lead responsibility for subsequent RI/FS efforts. The site has been assigned a Hazardous Ranking System score of 38.7 on the NPL.

In response to initiatives by the TDWR to secure remedial measures by previous owners of the site, the Koppers Company of Pittsburgh, Pennsylvania contracted with the Houston geotechnical consultants McClelland Engineers, Inc. (MEI) to perform further site investigations. An MEI report to Koppers, dated May 8, 1984, presents the results of that site study. Subsequently, Koppers contracted with the firm Environmental Research and Technology, Inc. (ERT) of Pittsburgh, Pennsylvania to propose a work plan for a RI/FS study on Koppers former Cavalcade Plant Site. A draft "Proposed Work Plan, Remedial Investigation/Feasibility Study, Koppers Company, Inc. Former Cavalcade Plant Site, Houston, Texas" dated December 13, 1984, presents a proposed RI/FS program for the Koppers Company.

In December, 1984, EPA authorized a work assignment for an RI/FS on the South Cavalcade Street Site to CDM under project REM II - EPA Contract No. 68-01-6939/143/WP1, Document Control No. 143-WP1-WA-ANNM-1. A Work Plan Memorandum by CDM for RI/FS on the South Cavalcade Street Site, dated December 31, 1984, has been submitted to the EPA.

2.2 CONTAMINATION PROBLEM

The South Cavalcade Street Site has a 70+ year history of industrial/commercial use with potential for long term contaminant pollution of the site. A report "Cavalcade Contaminant Survey", in three volumes by Camp Dresser & McKee, Inc. dated July 11, 1983, first documents the general nature and extent of site pollution. Section 3.0 presents review of data in this report.

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2.3 DESCRIPTION OF NATURAL FEATURES OF THE SITE

Present Land Use

The present land use of the South Cavalcade Street Site is predominately commercial, made up of several trucking firms. A southern tract of about 28.3 acres, facing onto Collingsworth Street to the south, is presently occupied by the Merchants Fast Motor Lines (14.9 acres in the ownership of Meridian Transport Company) on the southwest side of the tract, and 13.4-acres to the southeast owned by Rex King and occupied by Palletized Trucking, Inc.

A central tract of some 18.2 acres is also owned by the Meridian Transport Company and is presently idle (undeveloped) land. The 22.5 acre northern tract is owned by the Baptist Foundation of Texas and presently occupied by the Transcon Trucking Lines and AJF Leasing, Inc. The northern tract accesses to the north onto Cavalcade Street. Figure 2-2 displays the present property ownership of the site.

2-6

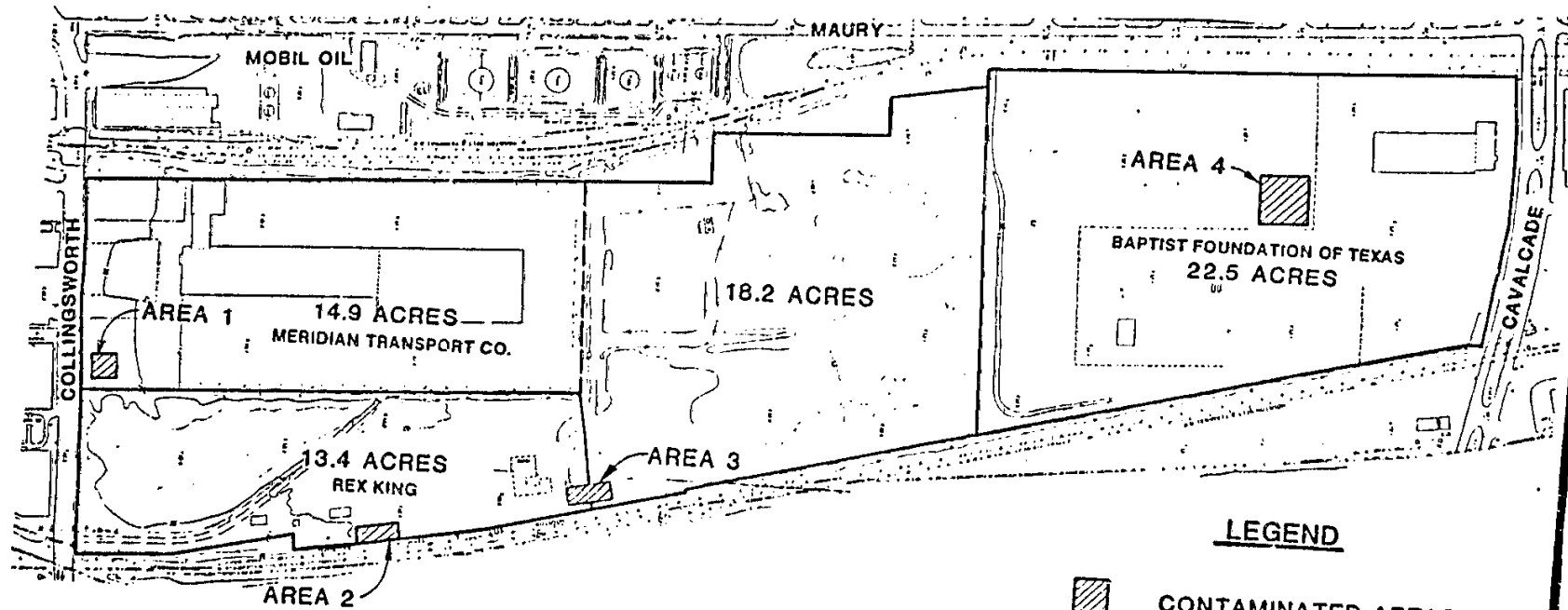


FIGURE 2-2
PRESENT OWNERSHIP & USE WITH CONTAMINATION AREAS

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Physiography

The general physiography of the site is a relatively flat plain with a very gentle slope to the south and east. Elevations range from about 50.0 feet mean sea level (msl) on the south to about 52.1 feet msl along Cavalcade Street to the north, an average slope of less than 0.15 percent. Drainage is generally to the south and east to local tributaries of Buffalo Bayou and the Houston Ship Channel.

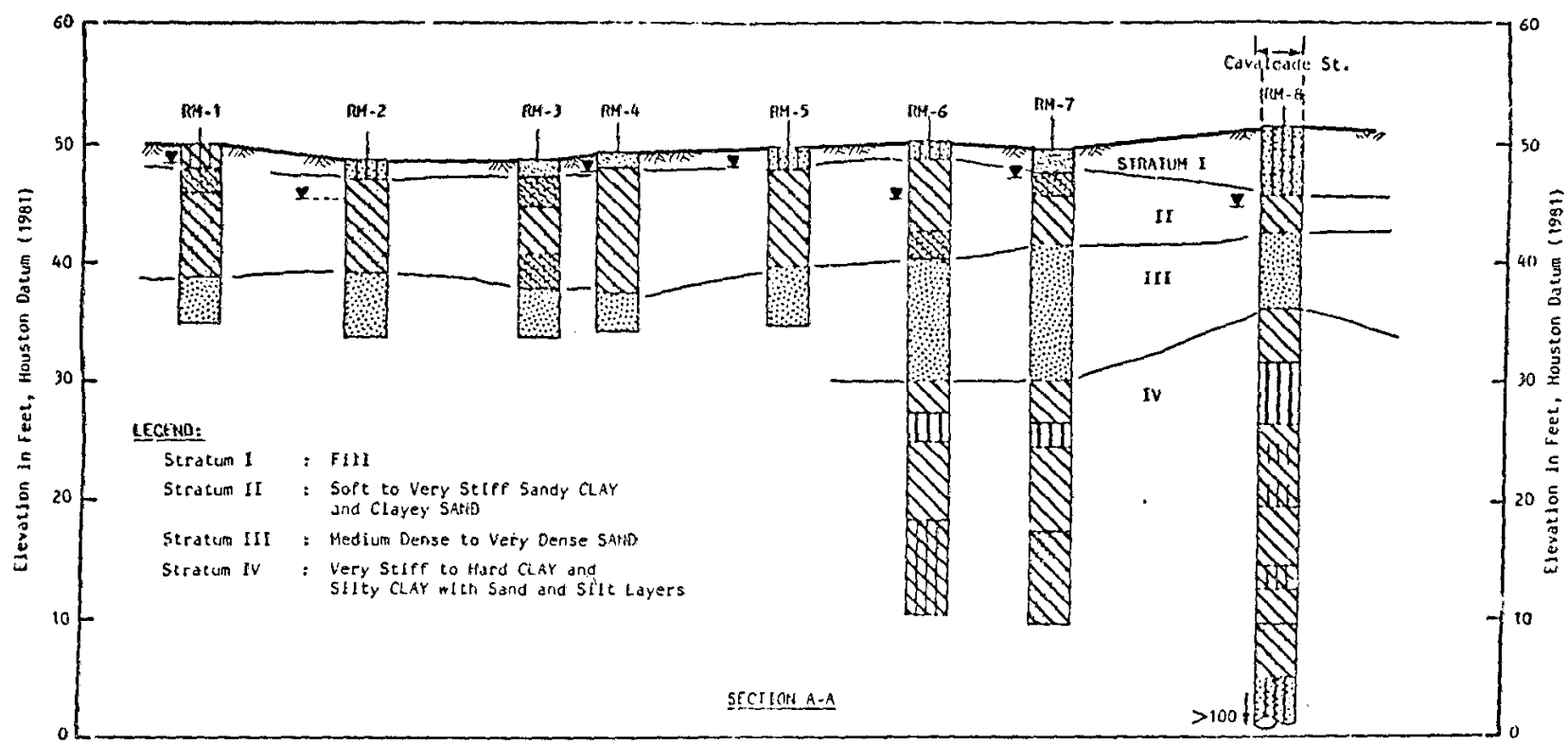
Soils

Local soil conditions have previously been investigated at the South Cavalcade Site (see McClelland Engineers Report No. 0182-0282, Volume II, dated May 20, 1983). A generalized soil profile of the site shows four distinct soil strata. Figure 2-3 depicts the soil conditions throughout the site based on reconnaissance borings. Although there are variations in strata elevation and thickness, the following generalized soil strata appear to the present throughout the site:

<u>Strata</u>	<u>Depth, ft.</u>	<u>Description</u>
I	0-2	Fill: silty fine sand
II	2-10	Soft to very stiff sandy clay and clayey sand
III	10-20	Medium dense to very dense fine sand
IV	20-80	Very stiff to hard clay and silty clay, with sand and silt layers

Figure 2-3 also indicates the presence, at the time of the reconnaissance soil borings in early 1983, of shallow water table conditions at depths of one to five feet beneath the surface throughout the site. The shallow sand strata (strata III in Figure 2-3) appear to be consistently present throughout the site and have a regional extent and significance off-site as well, as indicated by Figure 2-4. Typical shallow sand layers common to the Texas Gulf Coast area usually contain various amounts of silt. The relative permeability for sand strata will depend largely on the silt content, which varies significantly from place to place. Permeabilities will need to be determined on a site-by-site basis.

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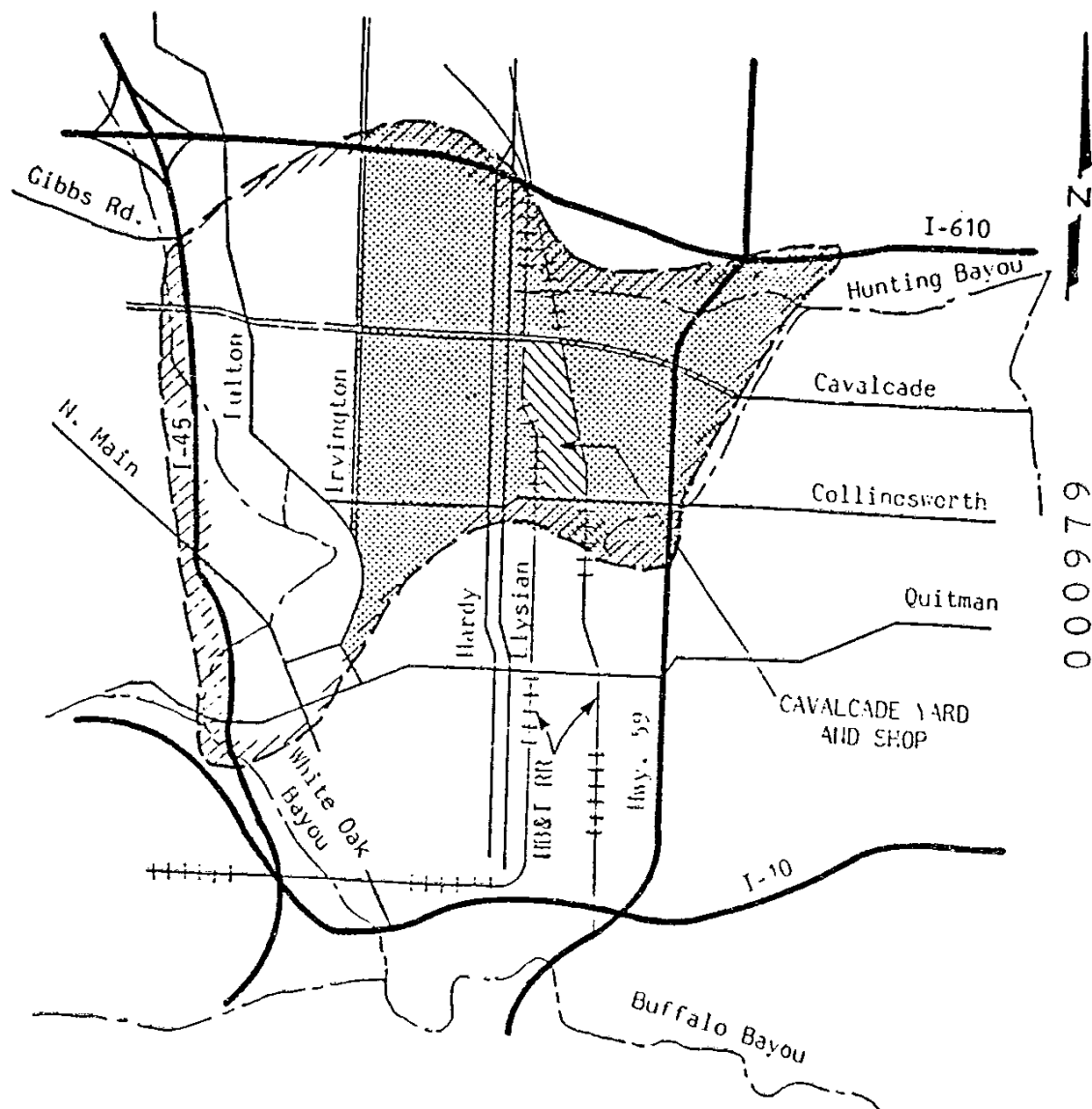
Notes:
 1. Data concerning subsurface conditions have been obtained at boring locations only. Actual conditions at locations between borings may differ from the generalized profile shown here.

Note:
 Information presented here was obtained from McClelland Engineers Report No. 0181-0546-2 dated September 30, 1982.

FIGURE 2-3
SOIL BORINGS & GENERALIZED SOIL PROFILE

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Note:
Shaded area indicates known areal extent of shallow sand layer, as determined through exploratory borings. Dashed line represents interpolated shallow sand layer area.

0 0.5 1 Mile

Note:
Information presented here was obtained from McClelland Engineers Report No. 0181-0546-2 dated September 30, 1982.

FIGURE 2-4
SHALLOW SAND STRATA MAP

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Geology

The geologic strata underlying the South Cavalcade Site consist principally of interbedded sands, silts, and clays of the Beaumont Formation, deposited in fluvial (river) and deltaic environments of the Pleistocene Epoch. Clay and silt materials predominate in the upper 200 to 300 feet of the Beaumont Formation, with thin discontinuous layers of sand occurring randomly. Thicker, more continuous sand deposits that occur in deeper parts of the Beaumont, also show extensive sand deposits in the upper strata of the formation.

Hydrology

Both the Lissie Formation and the lower Beaumont Formation are common sources of groundwater supplies in the Houston area although yields are small and considered inadequate for major exploitation. The deeper sands of the Chicote and Evangeline Aquifers, at depths of over 1,000 feet, are the local sources for major groundwater supplies.

11 The Beaumont Formation dips generally to the southeast. The regional dip of the strata and the presence of the interbedding sands and clays influence the regional hydrogeology of the entire area. Published geologic literature indicate that the principal areas of recharge for the Chicote and Evangeline Aquifers occur several miles north of the site area.

The predominately clay and silty soils in the upper strata of the Beaumont Formation, in conjunction with the southeastward dip of the formation, serve as a confining layer for the underlying Chicote Aquifer, producing artesian groundwater conditions in the aquifer. Discontinuous sand layers in the overlying Beaumont are considered too limited for effective recharge to the deeper aquifers.

Drainage

Surface drainage from the site consists of a system of poorly defined surface ditches, with storm water inlets and catch basins to convey runoff into the storm sewer system from the more developed areas on the south and north ends of the site. The undeveloped central part of the site is poorly drained, with surface ditches draining to runoff ditches along the east and west property borders in the railroad right-of-ways.

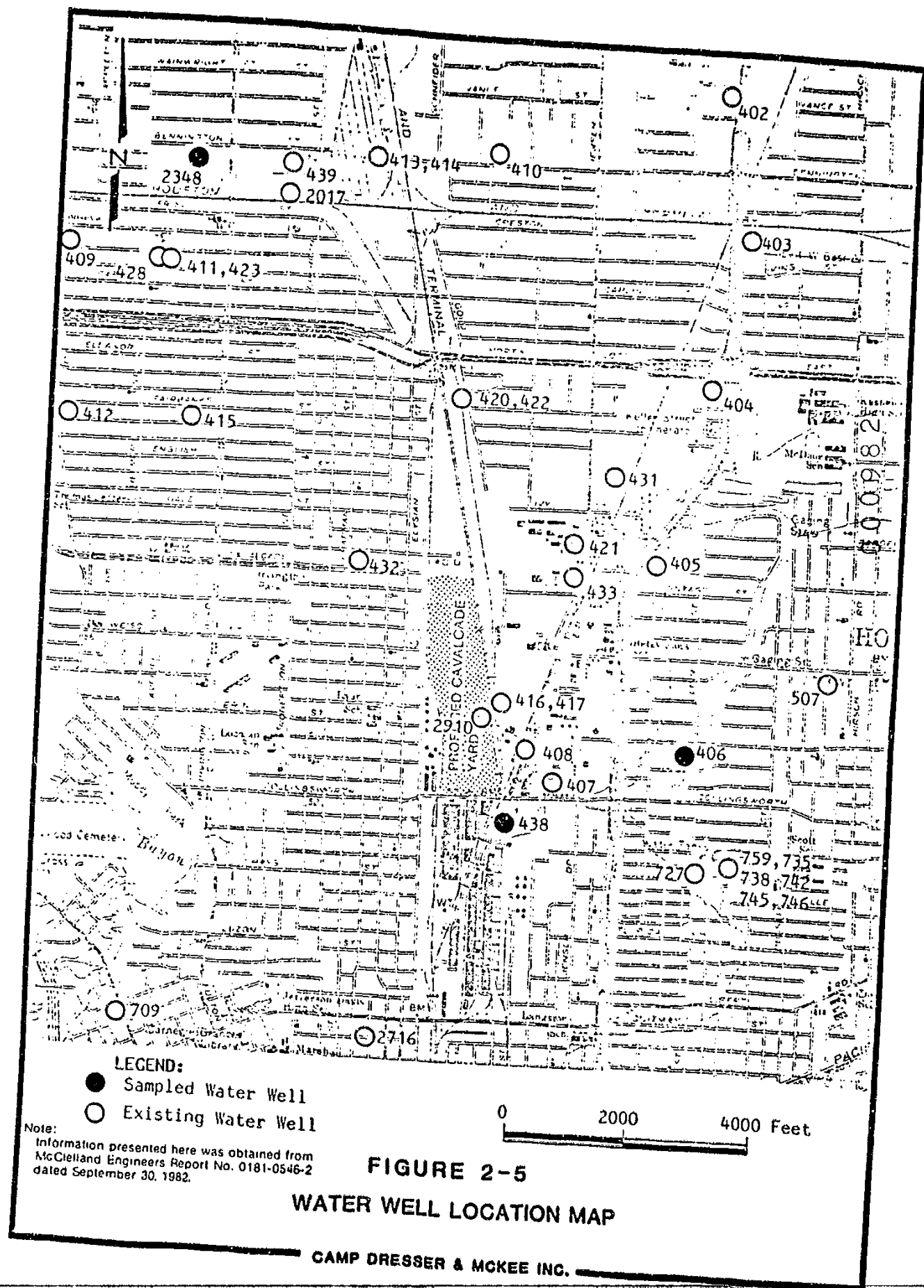
The southern two-thirds of the site drain generally to the south and east into a southern extension of Hunting Bayou, while the northern third drains to the east directly into Hunting Bayou. Hunting Bayou is a tributary to the Houston Ship Channel several miles downstream of the site.

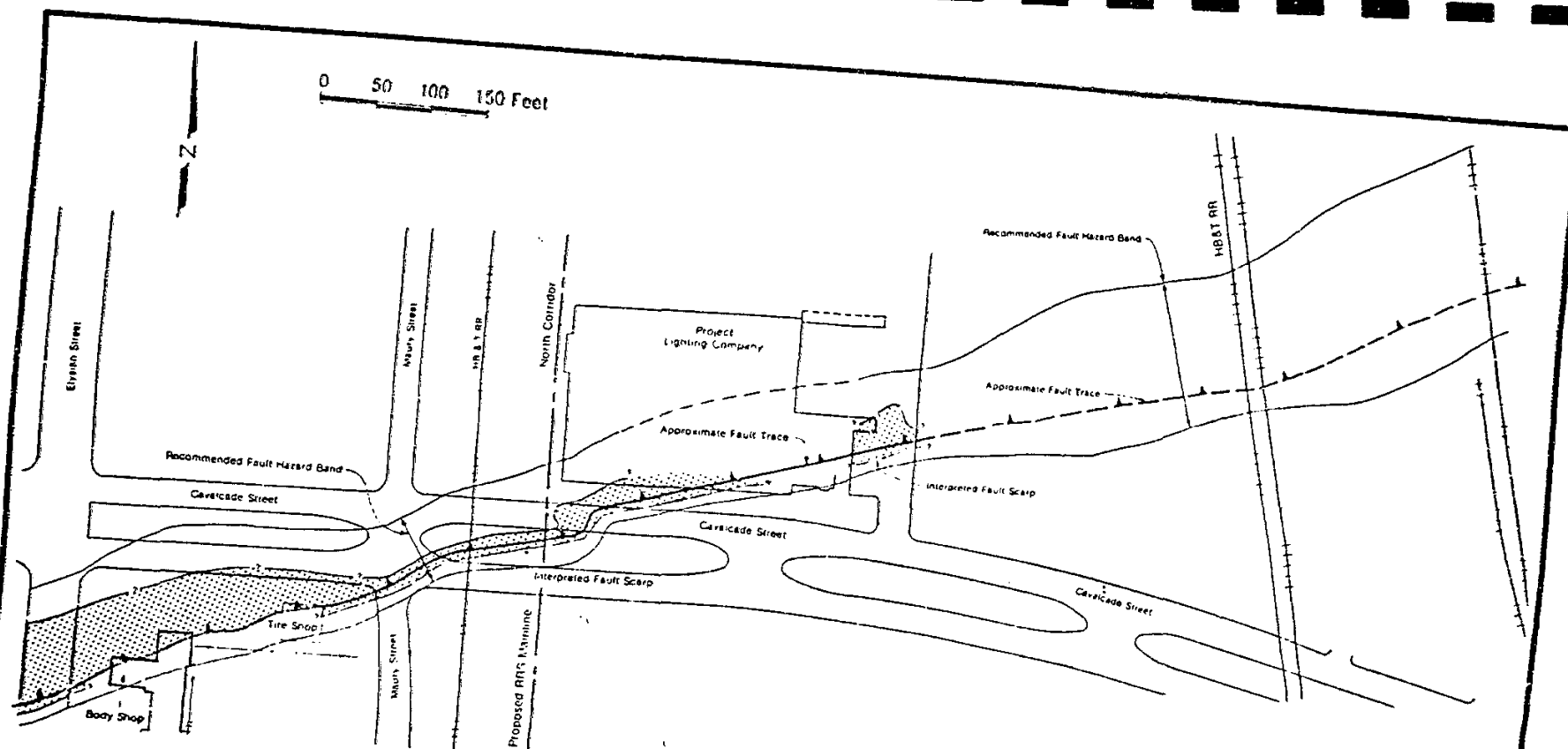
Groundwater

A survey of existing water wells in the vicinity of the South Cavalcade Site was conducted for the earlier McClelland Engineers study (report No. 0181-0546-2, dated September 30, 1982). Figure 2-5 depicts the location of existing wells in relation to the site. Three common strata used for groundwater supplies in the site area were identified. The more shallow of the local aquifers is located at elevations of about 170 to 220 feet below ground surface. This aquifer does not have a high yield and is restricted primarily to domestic uses. The second aquifer is found approximately at depths of 400 to 600 feet. This aquifer is developed locally for mainly industrial purposes. A third aquifer is located typically below 1,000 feet and is used primarily as a municipal supply for the City of Houston.

Faulting

The Pecore Fault is the only known active fault in the vicinity of the South Cavalcade Site. The fault trends approximately east-west and intersects the surface just north of Cavalcade street in the immediate vicinity of the site. The approximate mapped location of the Pecore Fault in the site vicinity is shown on Figure 2-6. The predicted annual differential movements across the fault are about 0.4 inches vertical and 0.1 inch





Note:
 Information presented here was obtained from
 McClelland Engineers Report No. 0181-0546-2
 dated September 30, 1982

FIGURE 2-6
 PECORE FAULT LOCATION

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horizontal. Many faults in the Houston area tend to act as partial hydro-geologic barriers to groundwater movements. Isolated portions of an aquifer may thus have different hydrogeologic characteristics due to local faulting. The extensive withdrawal of groundwater and petroleum supplies in the greater Houston area, resulting in active land subsidence, has caused accelerated fault movements during recent years.

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3.0 REVIEW OF EXISTING INFORMATION

A preliminary description of contaminants found at the South Cavalcade Site by previous investigations provides a basis for future remedial investigations. Any actual or potential health or environmental hazards already identified will be described as to types, physical characteristics and quantities, if known. The most probable pathways of exposure and escape of hazardous materials will also be described.

Recent 1982-83 investigations of the South Cavalcade Street Site for the Houston Metropolitan Transit Authority (MTA) revealed areas of localized soil and shallow groundwater contamination. McClelland Engineers, Inc. (MEI) performed a reconnaissance geotechnical survey in 1982 for MTA in relation to then pending plans for a Metro Regional Rail System (RRS). The MEI survey included general soil borings and preliminary foundation investigations for the proposed RRS yard and shop facility at the Cavalcade Site.

Creosote odors were detected during the MEI investigations and soil and groundwater samples were collected for analysis. Trace amounts of naphthalene and phenanthrene were identified and it was subsequently determined that the site was contaminated from previous wood preserving operations. It was recommended to MTA that additional investigations be conducted to assess the extent of the contamination problem.

In April of 1983, Camp Dresser & McKee, Inc. (CDM) was selected to perform a contaminant survey of the Cavalcade Site. A CDM report, in three volumes, entitled "Cavalcade Contaminant Survey", and dated July 11, 1983, provides a comprehensive assessment of their environmental study. CDM's site investigation program consisted of the following task activities for the South Cavalcade Site:

<u>TASK</u>	<u>PREFIX</u>	<u>NUMBER COMPLETED</u>
Sediment Sampling	SD	4
Surface Water Sampling	SW	2
Surface Soil Sampling	SL	4
Soil Borings	SL	10
Subsurface Soil Samples	SL	13
Shallow Observation Wells	OW	9
Deep Observation Well	OW	1
Production Well Sampling	PW	3

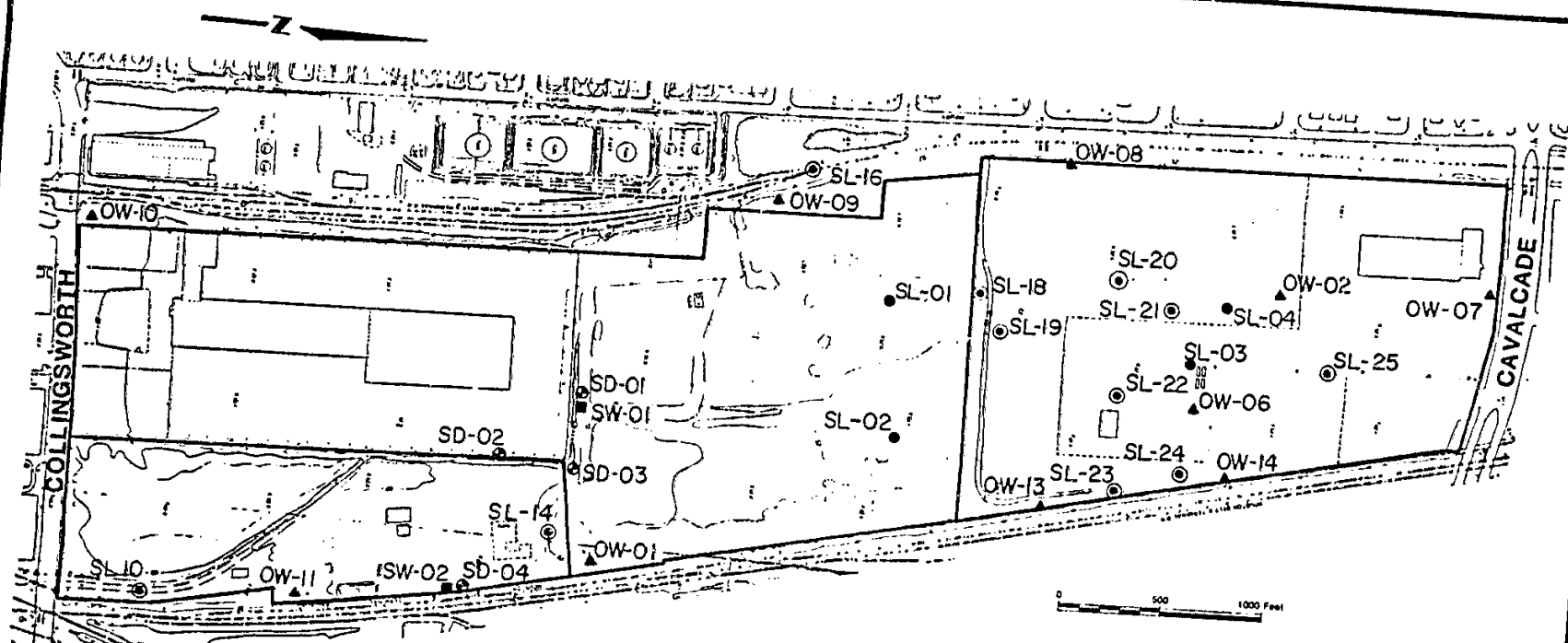
Comprehensive investigative results, methods and documentation are available in the three-volume report "Cavalcade Contaminant Survey" by CDM, in association with MEI, dated July 11, 1983. Results of the CDM contaminant survey are summarized in the following paragraphs.

3.1 SOIL INVESTIGATIONS

Soil borings at sites related to the locations of earlier wood treatment and coal tar distillation facilities during the 1911-1962 period were made to investigate subsurface contamination and migration of contaminants in the near-surface (to 40-foot depths) soil profile. All borings were confined to onsite locations. Figure 3-1 exhibits the locations of the soil boring localities.

Soil sampling depths and intervals were selected to best represent the probable pattern of contaminant concentration and movement. Sampling intervals were continuous from ground surface to 10 feet below ground surface for the deeper, 40-foot borings. Samples were taken for analysis at 5-foot intervals from the 10 to 40 feet depth. The shallow depth borings (10 feet) were at locations more remote from suspected areas of contamination and samples were taken at 2, 6, and 8-foot depths below ground surface at these borings.

In all cases, rotary drilling rigs were employed in conjunction with 3 inch thin wall Shelby tube samplers, 2 feet in length, which were attached to the bottom of the drill stem. Samples were taken by pressing the tube into undisturbed material at selected depths. The soil sampling analysis disclosed contamination with both organic and inorganic compounds in the



LEGEND

- ⊙ Deep Soil Sample
- Shallow Soil Sample
- Sediment Sample
- ▲ Surface Water Sample
- ▲ Observation Well

NOTE: SAMPLE LOCATIONS ARE APPROXIMATE.

Note:
Information presented here was obtained from
McClelland Engineers Report No. 0181-0546-2
dated September 30, 1982.

FIGURE 3-1
SAMPLING LOCATION MAP
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vicinity of suspected disposal areas, particularly near the soil surface. Concentrations of contaminants consistently decrease at greater depths in the soil profile.

CDM's soil boring program also provided visual and olfactory evidence of contamination in subsurface soil samples. All observations of soil contaminants were limited to areas of previously known or suspected waste disposal, with the exception of two off-site borings designated as SL-16 and SL-10 on Figure 3-1. These observations (SL-10 and 16) are probably not related to the previous users of the South Cavalcade Site, but to other commercial or industrial sources in the area.

3.2 SEDIMENT SAMPLING

Bottom sediment samples were collected from surface drainage areas at the southern end of the site. Locations of sediment sample collections (SD prefix) are shown on Figure 3-1. Detailed analytical results of the sediment sampling for toxic compounds are presented in Section 6.3, Vol. I of the CDM report. The only findings of significance were the presence of low-level refractory organic compounds, particularly the polynuclear aromatic hydrocarbons (PAH), as consistent with the site's history of wood preserving operations. Toxic metal contamination, although posing no significant environmental hazard, may prove to be a problem with respect to ultimate disposal. Results of analyses for contaminants in sediment samples are shown in Table 3-1.

3.3 SURFACE WATER SAMPLING

Two surface water samples were collected in conjunction with sediment sample locations SD-01 and SD-04. Surface water sample locations are designated SW-01 and SW-02 on Figure 3-1. No contamination of significance in local runoff water was detected at site SW-01 and only low-level contamination of PAH compounds was observed at the off-site SW-02 sample collected from runoff waters in the railroad drainage ditch. Results of laboratory analyses for contaminants in surface water samples are shown in Table 3-2.

TABLE 3-1
SEDIMENT SAMPLING ANALYTICAL RESULTS

Volatile Organics (all values PPB, ug/kg wet weight)

	<u>SD-01</u>	<u>SD-02</u>	<u>SD-03</u>	<u>SD-04</u>	<u>SD-05</u>
<u>Contaminant</u>					
Methylene Chloride	100	48	83	110	39

Refractory Organics (all values PPB, ug/kg, wet weight)

	<u>SD-01</u>	<u>SD-02</u>	<u>SD-03</u>	<u>SD-04</u>	<u>SD-05</u>
<u>Contaminant</u>					
Anthracene	240.	4700.	1600.	2100.	ND
Benzo(a)anthracene	550.	440.	620.	18000.	ND
Benzo(a)pyrene	500.	250.	600.	5400.	ND
3,4-Benzofluoranthene	1100.	890.	1300.	4800.	ND
Benzo(g,h,i)perylene	430.	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	210.	ND	ND	ND	ND
Chrysene	550.	530.	680.	14000.	ND
Floranthene	1100.	750.	1200.	25000.	320.
Indeno(1,2,3,-c,d)pyrene	320.	ND	600.	ND	ND
Phenanthrene	650.	ND	860.	14000.	ND
Pyrene	850.	690.	1100.	22000.	260.
Fluorene	ND	360.	ND	520.	ND
Aceraphthene	ND	ND	ND	580.	ND

Toxic Metals and Inorganics (all values PPM, mg/Kg, wet weight)

	<u>SD-01</u>	<u>SD-02</u>	<u>SD-03</u>	<u>SD-04</u>	<u>SD-05</u>
<u>Contaminant</u>					
Arsenic (As)	2.0	2.4	1.5	2.2	1.5
Beryllium (Be)	0.2	0.6	0.3	0.5	0.2
Cadmium (Cd)	0.8	0.6	1.0	1.4	ND
Chromium (Cr)	10.0	13.0	12.0	9.7	6.8
Copper (Cu)	13.0	60.0	21.0	82.0	21.0
Lead (Pb)	61.0	88.0	69.0	185.0	20.0
Mercury (Hg)	0.025	0.043	0.032	0.006	0.006
Nickel (Ni)	4.5	4.9	5.4	2.7	2.7
Silver (Ag)	0.40	0.06	ND	ND	ND
Thallium (Th)	ND	0.06	0.97	ND	ND
Zinc (Zn)	160.0	150.0	150.0	30.0	30.0

TABLE 3-2
SURFACE WATER SAMPLING ANALYTICAL RESULTS

Volatile Organics

No volatile organics detected.

Refractory Organics (all values reported as PPB, ug/l)

<u>Contaminant</u>	<u>SW-01</u>	<u>SW-02</u>
Benzo(a)anthracene	ND	10.
Benzo(a)pyrene	ND	10.
3,4-benzofluoranthene	ND	21.
Benzo(k)fluoranthene	ND	21.
Chrysene	ND	12.
Di-n-butyl phthalate	ND	18.
Fluoranthene	ND	17.
Pyrene	ND	14.

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Toxic Metals and Inorganics (all values removed as PPM, mg/l)

<u>Contaminant</u>	<u>SW-01</u>	<u>SW-02</u>
Cadmium (Cd)	0.05	ND
Zinc (Zn)	0.32	0.18

3.4 SURFACE SOIL SAMPLING

Four surface soil sampling locations, designated SL-01 thru SL-04 on Figure 3-1 were inspected for contamination. All samples were collected at locations suspected of prior use for disposal of creosote or other wood preserving products. Low-levels of volatile organics were detected at all four locations, with ethylbenzene at SL-04 of minor significance. The previously identified disposal areas, represented by SL-03 and SL-04, are highly contaminated with both PAH and toxic metals at the surface. All four sites indicate that use of an onsite treatment facility is questionable due to high toxic metal assays. Table 3-3 provides the results of contaminant analyses for surface soil samples.

3.5 SUBSURFACE SOIL SAMPLING

Multiple depths at each of 13 locations were sampled to determine the depth of contamination and the structure of the underlying soil profile. Sampling locations were selected at areas suspected of containing contamination or potential areas of future excavation for the RRS. Subsurface soil sampling sites are designated with the prefix SL on Figure 3-1. Details of the subsurface soil sampling program are found in Section 6.6 of the CDM report and are presented here in Table 3-4.

The previously identified contaminant areas (SL-03 and SL-04) are highly contaminated with both organic and inorganic (toxic metals) compounds at the surface and near-surface (to 5-foot depths). The level of contamination for most compounds decreases rapidly with depth. At SL-03, the contamination from polynuclear aromatic hydrocarbons decrease by a factor of 100 at the 10-foot depth, with similar declines in inorganic contaminants except for beryllium (Be), nickel (Ni) and silver (Ag). SL-04 demonstrates a similar attenuation of contamination with increasing soil depth, but required greater soil depths (15-foot depth for PAH's and 20-foot depth for most toxic metals) for similar levels of decline. An exception is a continuing high concentration of lead (Pb) at the 20-foot depth for SL-04.

TABLE 3-3
SURFACE SOIL SAMPLING ANALYTICAL RESULTS

Volatile Organics (all values PPB, ug/kg wet weight)

<u>Contaminant</u>	<u>SL-01</u>	<u>SL-02</u>	<u>SL-03</u>	<u>SL-04</u>
Methylene Chloride	59	39	59	ND
Ethylbenzene	ND	ND	ND	160
Toluene	ND ..	ND	ND	23

Refractory Organics (all values PPB, ug/kg, wet weight)

<u>Contaminant</u>	<u>SL-04</u>	<u>SL-02</u>	<u>SL-03</u>	<u>SL-01</u>
Acenaphthene	100,000	ND	780.	ND
Acenaphthylene	3,000	ND	2400.	ND
Anthracene	240,000	ND	12000.	ND
Benzo(a)anthracene	17,000	ND	32000.	200.
Benzo(a)pyrene	4,600	ND	21000.	ND
3,4-benzofluoranthene	10,000	ND	46000.	260.
Benzo(g,h,i)perylene	ND	ND	7200.	ND
Benzo(k)fluoranthene	10,000	ND	46000.	260.
Chrysene	11,000	ND	42000.	200.
Fluoranthene	260,000	ND	120000.	ND
Fluorene	80,000	ND	980.	ND
Indeno(1,2,3-c,d)pyrene	ND	ND	7200.	ND
Naphthalene	340,000	ND	1000.	ND
Phenanthrene	240,000	ND	2000.	ND
Pyrene	170,000	ND	110000.	10.
Di-n-octyl phthalate	ND	11	ND	ND

Toxic Metals and Inorganics (all values PPM, mg/kg, wet weight)

<u>Contaminant</u>	<u>SL-04</u>	<u>SL-02</u>	<u>SL-03</u>	<u>SL-01</u>
Arsenic (As)	0.35	2.5	82.0	1.8
Beryllium (Be)	0.29	ND	0.20	0.26
Cadmium (Cd)	0.88	ND	0.10	ND
Chromium (Cr)	12.0	7.6	79.0	14.0
Copper (Cu)	4.4	32.0	21.0	ND
Lead (Pb)	8.4	31.0	54.0	3.4
Mercury (Hg)	0.005	0.009	0.040	0.020
Nickel (Ni)	8.6	33.0	2.7	2.3
Silver (Ag)	0.7	ND	0.20	ND
Thallium (Tl)	ND	ND	0.10	ND
Zinc (Zn)	14.0	40.0	290.0	150.0

TABLE 3-4
SUBSURFACE SOIL SAMPLING ANALYTICAL RESULTS

SL-03 (All organic values PPB, ug/kg, all inorganic values PPM, mg/kg wet weight basis)

Volatile Organic	01	02	03
<u>Contaminants</u>	(2)	(5)	(10)
Methylene chloride	59	40	33
<u>Refractory Organic Contaminants</u>			
Acenaphthene	780.	ND	ND
Acenaphthylene	2400.	280.	ND
Anthracene	12000.	1000.	ND
Benzo(a)anthracene	32000.	5600.	ND
Benzo(a)pyrene	21000.	2000.	ND
3,4-Benzofluoranthene	46000.	6800.	ND
Benzo(g,h,i)perylene	7200.	1600.	ND
Benzo(k)fluoranthene	46000.	6800.	ND
Chrysene	42000.	4500.	ND
Fluoranthene	120000.	24000.	ND
Fluorene	580.	ND	ND
Indeno(1,2,3-c,d)pyrene	7200.	1800.	ND
Naphthalene	1000.	ND	ND
Phenanthrene	20000.	5800.	ND
Pyrene	110000.	20000.	ND
SL-03	01	02	03
	(2)	(5)	(10)
<u>Toxic Metal Contaminants</u>			
Arsenic (Ar)	82.0	1.5	0.33
Beryllium (Be)	0.20	0.20	0.20
Cadmium (Cd)	0.10	ND	ND
Chromium (Cr)	79.0	14.0	3.4
Copper (Cu)	21.0	1.9	1.3
Lead (Pb)	54.0	7.2	7.2
Mercury (Hg)	0.040	0.620	0.009
Nickel (Ni)	2.7	3.0	2.1
Silver (Ag)	0.20	ND	0.88
Thallium (Tl)	0.10	ND	ND
Zinc (Zn)	290.0	23.0	3.6

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TABLE 3-4 (continued)

SL-04 (all organic values PPB, ug/kg, all toxic metal values PPM mg/kg,
wet weight basis)

Volatile Organic

	01 (2)	02 (5)	03 (10)	04 (15)
<u>Contaminants</u>				
Ethylbenzene	160	98	10	ND
Methylene chloride	ND	52	73	ND
<u>Refractory Organic Contaminants</u>				
Acenaphthene	100000.	360000.	80000.	54000.
Acehaphthylene	3000.	ND	3200.	ND
Anthracene	240000.	520000.	48000.	580.
Benzo(a)anthracene	17000.	27000.	28000.	320.
Benzo(a)pyrene	4600.	7600.	32000.	460.
3,4-Benzofluoranthene	10000.	16000.	7200.	340.
Benzo(g,h,i)Perylene	ND	ND	5000.	ND
Benzo(k)fluoranthene	10000.	16000.	7200.	340.
Chrysene	11000.	20000.	36000.	320.
Dibenzo(a,h)anthracene	ND	ND	5000.	ND
Fluoranthene	260000.	440000.	120000.	2000.
Fluorene	80000.	110000.	64000.	340.
Indeno(1,2,3-c,d)pyrene	ND	ND	ND	ND
Naphthalene	340000.	640000.	200000.	ND
Phenanthrene	240000.	1100000.	180000.	4400.
Pyrene	170000.	280000.	88000.	1400.
2,4-Dimethylphenol	ND	ND	ND	ND
SL-04				

Toxic Metal

	01 (2)	02 (5)	03 (10)	04 (20)
<u>Contaminants</u>				
Arsenic	1.8	2.0	1.2	0.29
Beryllium	0.26	0.28	0.6	0.31
Cadmium	ND	ND	0.5	ND
Chromium	14.0	4.1	8.1	3.7
Copper	ND	0.56	7.7	1.2
Lead	3.4	0.37	9.1	6.4
Mercury	0.020	0.005	0.004	0.005
Nickel	2.3	3.70	15.0	4.50
Silver	ND	ND	1.2	ND
Zinc	15.0	23.0	24.0	5.8

3.6 SHALLOW GROUNDWATER SAMPLING

Nine shallow groundwater observation wells were located on the South Cavalcade Site to determine the extent of groundwater contamination in the upper (shallowest) aquifer beneath the site and to determine the direction of flow of the local groundwater system. Selected wells located near the suspected contamination areas (OW-01 and 02) were sampled for organic contamination. During the upper (shallow) aquifer groundwater sampling program, the organic contamination detected was consistent with previously detected surficial contaminants, except for concentrations for volatile organics (benzene, ethylbenzene and toluene) observed in groundwater samples from OW-02. These aromatic hydrocarbons are more consistent with recent hydrocarbon (petroleum products) contamination. OW-01 showed no detectable volatile organics and significantly fewer and smaller concentrations of refractory organics than found in the groundwater at the OW-02 well site. Table 3-5 provides the results of contaminant analyses of the shallow groundwater samples.

The levels of toxic metal contamination found in the upper aquifer groundwater are within EPA primary and secondary drinking water standards. The high levels of toxic metal contamination found in surface soil samples at these locations are not reflected in associated shallow groundwater samples. This indicates that the toxic metals are not in mobile forms migrating downward through the soil.

The cyanide concentration observed in both wells OW-01 and OW-02 are inconsistent with any known previous industrial source at this site. The presence of cyanide in the shallow groundwater may indicate an off-site source of cyanide compounds in the area.

3.7 DEEP GROUNDWATER SAMPLING

A deep (200 foot) groundwater monitoring well, designated as OW-06 on Figure 3-1, was installed and sampled to determine the extent of possible groundwater contamination in a lower aquifer, used in the area as a source

TABLE 3-5
SHALLOW GROUNDWATER SAMPLING ANALYTICAL RESULTS

Volatile Organics (all values reported as PPB, ug/l)

	OW-01	OW-02
<u>Contaminants</u>		
Benzene	ND	21
Ethylbenzene	ND	58
Toluene	ND	110

Refractory Organics (all values reported as PPB, ug/l)

	OW-01	OW-02
<u>Contaminants</u>		
2,4-Dimethylphenol	ND	680
Pentachlorophenol	ND	66
Phenol	ND	59
Acenaphthene	49	380
Acenaphthylene	17	30
Benzo(a)pyrene	NA	29
Bis(2-ethylhexyl) phthalate	ND	17
Butyl benzyl phthalate	ND	17
Di-n-butyl phthalate	ND	34
Fluoranthene	23	34
Fluorene	73	300
Naphthalene	670	17000
Phenanthrene	160	240
Pyrene	17	27

Toxic Metals and Inorganics (all values reported as PPM, mg/l)

	OW-01	OW-02
<u>Contaminant</u>		
Arsenic (As)	ND	0.13
Copper (Cu)	0.06	ND
Zinc (Zn)	0.12	0.20
Total Cyanide (Cn)	0.70	0.10

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of domestic water supply. A representative groundwater sample was collected following well stabilization. Two soil samples were collected from soil immediately above and below the well screen depth. The groundwater samples and the two soil samples were analyzed for appropriate organic and inorganic contaminants and are shown in Table 3-6.

With the exception of trace concentrations of toluene in the groundwater sample, the deep (200-foot) aquifer and the associated soil samples were uncontaminated with any other organic compounds. Inorganic contaminants are present in detectable concentrations in the deep soil samples, but only antimony (Sb), arsenic (As) and selenium (Se) were observed in the groundwater sample. The inorganic compounds (particularly arsenic and selenium) are present only at low concentrations (As-.05, Se-.26) within primary drinking water standards and present no public health or environmental threat. The presence of arsenic at 12.0 mg/kg in the soil samples may indicate a rather high natural background of this toxic material in the local clay substrata.

3.8 PRODUCTION WELL SAMPLES

Selected production wells located within close proximity to the site were sampled to determine the extent of any external migration of contaminants. Production well depths ranged from 300 to 500 feet below ground surface. Sampled production wells, labeled PW-01, 02, and 03 on Figure 3-1, proved to be uncontaminated with any detectable organics. Inorganic concentrations in excess of primary drinking water standards were observed in PW-01 for lead (0.36 ppm), in PW-02 for both cadmium (0.04 ppm) and lead (0.35 ppm) and in PW-03 for lead (0.30 ppm). Table 3-7 provides contaminant analysis for the deep production well samples.

TABLE 3-6
DEEP GROUNDWATER SAMPLING ANALYTICAL RESULTS

Volatile Organics (all values reported as PPB, ug/l)

	OW-06	SL-11 (Soil)	SL-19 (Soil)
<u>Contaminant</u>	(06)	(11)	(19)
Toluene	49	ND	ND

Refractory Organics

No Compounds detected.

Toxic Metals and Inorganics (all values reported as PPM mg/l or mg/kg wet weight)

	OW-06	SL-11 (Soil)	SL-19 (Soil)
<u>Contaminant</u>			
Antimony (Sb)	0.1	ND	ND
Arsenic (As)	0.05	12.0	12.0
Beryllium (Be)	ND	9.30	0.31
Cadmium (Cd)	ND	0.30	0.31
Chromium (Cr)	ND	17.0	2.4
Copper (Cu)	ND	06	4.0
Lead (Pb)	ND	5.7	7.5
Mercury (Hg)	ND	9.003	ND
Nickel (Ni)	ND	1.5	4.6
Selenium (Se)	0.260	ND	ND
Silver (Ag)	ND	ND	ND
Thallium (Tl)	ND	2.1	1.9
Zinc (Zn)	ND	3.1	7.3

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TABLE 3-7
DEEP GROUNDWATER SAMPLING ANALYTICAL RESULTS
(PRODUCTION WELLS)

Volatile Organics

No volatile organic compounds detected.

Refractory Organics

No refractory organic compounds detected.

Toxic Metals and Inorganics (all values reported as PPM, mg/l)

<u>Contaminant</u>	<u>PW-01</u>	<u>PW-02</u>	<u>PW-03</u>
Cadmium (Cd)	ND	0.04	ND
Lead (Pb)	0.35	0.35	0.30
Zinc (Zn)	0.58	0.52	0.28

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4.0 POTENTIAL IMPACTS, EXPOSURE OR CONTAMINANT RELEASE

A preliminary assessment of the available site characterization data summarized above can provide useful direction to the prediction of potential onsite and off-site impacts of possible contaminant exposure or release to other environments. Two principal hazard areas of potential health or environmental impacts can be identified from preliminary assessment of the data. These are the surface and near-surface contamination of the soil materials in the immediate vicinity of previously identified disposal areas, and the associated shallow groundwater contamination observed in the same general areas. Surface water impacts are probably not significant health or environmental concerns based upon preliminary findings and current conditions, use and location. Deep percolation and contamination of local groundwater aquifers used for domestic, industrial or municipal water supplies are also considered to be non-threatening to public health or the environment.

4.1 SURFACE AND NEAR-SURFACE CONTAMINATION

Residual contaminants from earlier wood preserving and coal tar distillation activities at this site are restricted mainly to surface and near-surface (10-foot depths, or less) contamination with both organic (polynuclear aromatic hydrocarbons) and inorganic (toxic metal) compounds in the immediate vicinity of previous disposal areas.

The potential impacts of the surface and near-surface soil contamination in these areas are as sources of continued shallow groundwater contamination, and as sources of contaminant release to local environments from future development or use of the site. The soil contaminants do not appear to be an imminent threat to health or the environment due to volatilization, direct contact, or surface runoff exposures under present conditions.

4.2 SHALLOW GROUNDWATER CONTAMINATION

The groundwater sampling program conducted by CDM indicated that the shallow water table conditions at the site and the shallow sand strata (strata III on Figure 2-3) are locally contaminated with both PAH and toxic metal compounds, as consistent with the surface soil contamination observed in and near the previous disposal areas. The aerial extent of present groundwater contamination is not yet known, however, due to the limited groundwater sampling carried out during the CDM contaminant survey. It is possible, however, that the shallow groundwater contamination is extensive, even extending off-site. More comprehensive sampling of local groundwater conditions will be necessary to determine the extent and rate of migration of contaminants in the shallow groundwater in and near the site. It was not evident at the time of CDM's work that the contamination of the shallow groundwater in the vicinity of the South Cavalcade Site poses any imminent threat to public health or the environment. There are no known users of the shallow groundwater, no known surface exposures such as ponds or standing water, and no known present concerns with discharges from the shallow sand strata to local surface drainage.

It is very likely that the shallow groundwater is also contaminated by a variety of local urban and industrial sources. Contamination of the deeper aquifers in the area, which are known to be used for domestic, industrial or municipal water supplies, was not considered by CDM to be a significant threat to public health or the environment.

5.0 REFERENCE DOCUMENTS

1. U.S. EPA Region VI File Documents. Copies of relevant EPA file documents on the South Cavalcade Site have been provided to CDM.
2. Texas Department of Water Resources File Documents. Pertinent information on file with the TDWR in relation to state regulatory actions for the site are included in a comprehensive microfiche file made available to CDM by TDWR. Files include correspondence, telephone memos, site summary, report excerpt, TDWR site investigation report and other documentation.
3. Texas Natural Resources Information System. Physical site data, remote sensing data, and other relevant site characterization information is readily available to CDM from the TNRIS Austin, Texas facilities. An index of available aerial photographic coverage of the site has been secured from TNRIS and appropriate photos selected and ordered.
4. U.S. Geological Survey. Recent USGS 7.5⁰ quad sheets for the site and immediately surrounding areas have been obtained by CDM.
5. City of Houston. Land use and storm/sanitary sewer maps of the area of the site have been obtained from the Houston Public Works Department.
6. CDM Report and Files. The report "Cavalcade Contaminant Survey" in three volumes, dated July 11, 1983, is on-hand at CDM's Austin office, along with original data base for the report.
7. McClelland Engineers Reports. The MEI report "Reconnaissance Geotechnical Study, Proposed Cavalcade Yard Site" No. 0882-0282, dated May 20, 1983 is on-hand at CDM's Austin office. Their follow-up report to Koppers Company Inc. dated May 8, 1984, has been requested but not yet received.

8. Koppers Company, Inc. Koppers Company correspondence with TDWR and a copy of the report "Proposed Work Plan, Remedial Investigation/ Feasibility Study Koppers Company Inc. Former Cavalcade Plan Site, Houston, Texas" dated December 13, 1984, are on-hand at CDM Austin.

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APPENDIX

SITE INSPECTION MEMORANDUM

001004

M E M O R A N D U M

TO: R.A. Kier CDM/Austin
FROM: J.D. Gram CDM/Boston
DATE: 4 February 1985
PROJECT: EPA Contract No: 68-01-6939
DOCUMENT NO.: 143-WP1-10-ASHM-1
SUBJECT: Cavalcade South - Site Inspection Report
ACTION: Review and Comment

Objectives: The objective of the site inspection was to confirm the site description contained in the 1983 CDM report and to identify any changes in site conditions that may have occurred since that time. Prior to conducting the site inspection the available site information was reviewed. The Existing Information Memorandum Report was not available for review prior to conducting the Initial Site Characterization inspection because the site inspection request was made by EPA-Region VI to coincide with the TAT inspections. Therefore, a complete review of available information on site activities could not be conducted.

Introduction

A site inspection was performed at the South Cavalcade Site, Houston, Texas on January 16, 1984. The site is currently bounded by the Houston Belt Terminal railroad tracks to the east, Cavalcade Road to the north, Missouri Pacific railroad tracks to the west, and Collingsworth Road to the south. The site currently consists of approximately 45 acres on a parcel of land 1-1/2 miles southwest of the intersection between Loop 610 and U.S. Route 59 (Eastex Freeway).

The majority of the site area has formerly been used as a production facility for creosote and other wood preservative products. From 1911 to 1939 the was operated by the National Lumber and Creosoting Company. This operation consisted of a production facility on the southwest corner of the site and "dripping" and drying areas toward the center and northern areas of the site. National Lumber and Creosoting Company operation was purchased by the Koppers Company in 1940. In addition to the wood preserving operation, a coal tar distillation process facility was also constructed and operated in the southeast corner of the site. Numerous ponds, tanks, and possibly lagoons by Koppers existed the site. Two known buried ponds or lagoons (noted on historical aerial photographs and boring logs) existed in the southwest corner of the site and in the center northern area of the site. The facility was closed by Koppers in 1962. All plant building were removed and the site area was covered with soil. Currently, three palletized trucking firms have operations located within the site boundaries; Meridian Transport Company (Merchants Fast Motorized Lines) in the central and southwestern corners of the site, Palletized Trucking Inc. in the southeastern corner of the site and Transcon Trucking Lines, ion the northern portion of the site. AJF Leasing also operates within the property boundry on the northeast corner of the site. Both AJF and Transcon-operations are on a portion of the site owned by the Baptist Foundation of Texas.

In the early 1980's, the Harris County Metropolitan Transit Authority (MTA) became interested in the site for a combined railyard, shop, and station for a proposed light rail transit system. During routine geotechnical investigations by McClelland Engineers Inc. (MEI) for preliminary design purposes, several localized areas were found to be contaminated with creosote waste products. Camp Dresser & McKee Inc. (CDM) was then retained to perform a contaminant survey and to develop remedial measures that would mitigate the contamination and allow use of the land by MTA. During the course of CDM's work MTA revised their construction plans to largely exclude the area north of Cavalcade Street. CDM's report, "Cavalcade Contaminant Survey", dated July 11, 1983, documented the presence of soil and shallow groundwater contaminated with creosote waste products and heavy metals. Contaminants encountered on the site include chrysene, flouranthene, arsenic chromium, lead, naphthalene, pentachlorophenol, and zinc. Failure of a bond issue in May 1983 resulted in the termination of CDM's work prior to selection of an appropriate remedial alternative and site remediation.

Health and Safety

Prior to conducting the initial site inspection available information on the South Cavalcade site to CDM was reviewed and the Site Evaluation Form (SEF) was completed to identify the health and safety requirements necessary to conduct the initial site inspection. Based upon the SEF, the Initial Site Characterization could be performed in Level D personnel protection with the contingency to upgrade to Level C, if necessary. A copy of the complete SEF forms for the site inspection is attached.

Personnel and Responsibilities

The site characterization was performed by the REM II contractor team using the following individuals:

Richard S. Lawlis - CDM/Austin
Jeffrey D. Gram - CDM/Boston

Also presented at the site during the Initial Site Characterization were:

John Cochran - USEPA - Region VI/Dallas
Kevin Jackson - R.F. Weston - TAT/Dallas
Warren Zehner - R.F. Weston - TAT/Houston

Prior to going on-site it was determined that REM-II contractor team members were responsible to perform all monitoring with the specified on-site instrumentation. Based upon the SEF for the site, Jeffrey D. Gram conducted an on-site briefing on potential site health and safety concerns, previous remedial investigation activities, identified site hazards and site inspection procedures. It was designated that Richard S. Lawlis would perform monitoring with the HNu photoanalyzer and Jeffrey Gram would monitor with the AID and Ludlum meters respectively. All other personnel present during the inspection had no on-site responsibilities and were observers only.

Equipment

Personnel monitoring instruments used during the investigation consisted of the HNu photoanalyzer with a 10.2 ionization potential lamp, AID Hydrocarbon Analyzer with a flame ionization detector, and a Ludlum radiological monitoring instrument with a Beta/Gamma pancake probe. Poor weather during the investigation restricted the use of both the AID Hydrocarbon Analyzer and the radiological monitoring instrument. Prior to going on-site, background levels were measured with the instruments. Initial readings with the HNu indicated that Level D would be satisfactory to conduct the site characterization. Areas of concern identified in the previous investigation were examined with the HNu to determine potential impact to the surrounding ambient environment.

Account of Site Inspection

The site characterization inspection was started at the northern end of the site. Initially, the inspection was conducted on foot in the areas of the northern lagoon area. Monitoring with the HNu in this area revealed no levels of organic vapors above measured off-site background. Access to the on-site monitoring wells could not be obtained therefore organic vapor headspace concentrations could not be measured. Surficial soils in this northern area had some noticeable areas of darkened/stained areas.

The site inspection then was conducted in the central third area of the site. This was conducted by vehicle with location of monitoring wells identified. Previous remedial investigation activities revealed no surficial contamination evident in this area. This portion of the site was covered with heavy vegetation.

The southern portion of the site was then inspected. This area was examined by foot and air vapors monitored with the HNu. No values above background were noted with the instrument. The area of the southern lagoon was identified as well as the location of the former coal distillation facility. The area around the portion of the site presently owned by Palletized Trucking fenceline, a pile of debris which appeared to be contaminated with the creosote existed. Monitoring with the organic vapor did not indicate elevated readings. A portion of the area owned by Palletized Trucking also appeared to have some contamination present. The area could not be examined in further detail because of site access problems.

The site inspection was conducted in Level D personnel protective equipment and no upgrade to Level C required. The site inspection lasted approximately 2 hours.

Summary

Based upon observations made during the Initial Site Characterizations the following site characteristics can be noted:

Topography - The site is level with no distinct elevated or depressed areas. Based upon review of the USGS 7 1/2 minute topographic the land surface of the site slopes gently map a gentle slope throughout the region

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of the site exists toward the southeast with a elevation in the northwest corner of approximately 55 feet above sea level and an elevation of approximately 50 feet above sea level on the southeast corner. Observation of the local surface water drainage patterns would confirm this regional topography.

Geology - Surfically, exposed soils within the site boundaries consist of a grey silty fine sand. During the previous remedial investigation conducted by Camp Dresser & McKee Inc.; at a total of 15 soil borings were drilled ranging in depths from 15 to 80 feet within the South Cavalcade Street site. These soil borings generally indicated four distinct soil strata varying slightly throughout the area of the site. Although there are some variations in the elevations and thicknesses of the strata, the following generalized soil strata appear to be continuous throughout the site.

Stratum	Depth	Description
I	0-2	Fill: Silty fine sand
II	2-10	Sandy clay and clayey sand
III	10-20	Very dense fine sand
IV	20-80	Very stiff clay and silty clay

Hydrogeology - As part of the remedial investigation conducted previously, a total of nine (9) shallow groundwater monitoring wells and one deep groundwater monitoring well were installed within the boundaries of the site. During this groundwater investigation it was determined that the principle groundwater regime which is contained within the site boundaries consists of three primary water bearing layers located at depths of approximately 20, 250, and 550 feet respectively. All of these groundwater aquifers are part of the Beaumont formation, which is generally found in the Texas Gulf Coast area. The nine shallow monitoring wells installed at the site were screened in the upper aquifer, while the deep well was installed in the aquifer in the approximately 250. Based upon foot aquifer elevations of groundwater measured during the remedial investigations, it was determined that in the shallow aquifer, higher groundwater elevations exist on the eastern boundry of the property and slo; toward lower elevations on the western boundry for the shallow waterbearing layer. It also appears that there is a groundwater mound in the center portion of the site and extend westward.

Surface Hydrology - Surface water drainage exists in the southern portion of the site is primarily in the form of drainage ditches located in the southeastern corner of the site and a storm sewer which was installed to service the trucking companies. A drainage ditch on the western boundry of the site also exists to service the railway and to provide drainage to a small portion of the southwestern area of the site. The remainder of the site is poorly drained. Regionally, drainage is provided by the Hunting Bayou to the east of the site, and Little White Oak Bayou to the west. It was concluded from the previous remedial investigation that the shallow waterbearing layer (approximately 20 feet in depth) may intersect these bayous. Little White Oak Bayou eventually discharges to Buffalo Bayou to the south of the site. Both Buffalo and Hunting bayous eventually discharge to the Houston Ship Channel.

Quality - Air quality at and in the vicinity of the South Cavalcade Street Site appears to be representative of regional air quality. Monitoring, performed during the previous remedial investigation and Initial Site Characterization with an HNu Photalyzer with 10.2 ionization potential lamp indicated no levels above background in locations throughout the site. During the subsurface investigation conducted as part of the remedial investigation, elevated readings were observed from visually contaminated soils. With the current situation, no potential exists for contamination from the site to regional air quality unless subsurface soils are exposed.

Land Use - As previously identified the site is currently occupied by trucking firms on the north and the south and is vacant in the center third of the site. To the southwest of the site there is an oil distribution center operated by Mobil Oil. This operation consists of several above ground storage tanks, a tank truck filling network and an underground pipeline. Elsewhere on the west side of the oil distribution center are heavily populated neighborhoods to the west. North of the site is the North Cavalcade Street another site, uncontrolled hazardous waste site. Currently surface property on this area is occupied by two warehouse facilities. The adjacent property to the south and east of the site boundaries is commercial areas, occupied by additional trucking firms, an iron foundry, and an acetylene production facility.

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Site Contamination - Based upon information obtained during the Initial Site Characterization and the previous remedial investigation the following areas of contamination can be identified:

1) Surficial Contamination - During the Initial Site Characterization two areas of exposed contamination were found on the eastern boundary of the site near the railroad tracks and drainage ditch. One area consisted of a pile of demolition materials from the old tar plant. This pile consisted of old timbers and building materials that were visibly contaminated with creosote or wood preserving products. Monitoring of the area with the HNu revealed no elevated readings, however the second area consisted of a patch of exposed contaminated dark stained soils perhaps creosote. Monitoring of this area with the HNu could not be performed because of site access restrictions. However, a noticeable odor was detected and an oily film appears on the surface of the water in the drainage ditch. Some areas on the northern portion of the site appeared to be devoid of vegetation and contained stained soils. It is assumed this area became contaminated from the dripping/drying process.

2) Subsurface Soil Contamination - From information collected during the previous remedial investigation, evidence of extensive subsurface soil contamination exists. Three known areas of contamination were identified as: 1) The area in vicinity of the old coal distillation facility in the southeast corner of the site; 2) An old lagoon associated with the creosote production facility in the southwest corner of the site; and 3) A second lagoon located approximately 1000 feet south of Cavalcade road in the center of the site. All three of the areas have been covered with surficial soils. The soil borings also indicate that the contamination does not exist of 50 feet below the ground surface. Samples collected from the suspected lagoon areas showed visual signs of creosote contamination and elevated readings on the HNu photoanalyzer.

3) Groundwater Contamination - Evaluation of groundwater collected from the on-site monitoring wells indicate extensive contamination of the shallow waterbearing layer (< 20 ft). Samples collected display visual discoloration, and analytical results indicated contamination with a wide variety of compounds associated with creosote and wood products. Analytical results from samples collected from the deep groundwater monitoring well (250 ft aquifer) indicates no contamination of the deeper groundwater. Samples collected from off-site private groundwater wells indicated no contamination associated with the site in deeper groundwater.

Recommendations

Based upon the limited previous remedial investigation conducted at the South Cavalcade Street Site, remediation alternatives were identified. The South Cavalcade Street recommendation of the limited feasibility analysis performed on the Site was to excavate known contamination areas and cap the entire site with clean compacted clay fill. Other site remediation alternatives identified during the limited feasibility study consisted of:

- o No Action
- o In-Situ Chemical Fixation
- o Incineration
- o Removal Disposal

The feasibility study evaluated these proposed remedial action for appropriateness against some specified criteria and concluded that the recommended alternative is as most acceptable considering the intended use of the site.

Observations made during the site characterization reveal surface activities for the remedial investigation can be conducted in Level D personnel protection, provided adequate foot and hand protection is provided. Subsurface activities should be performed in Level C with the contingency to upgrade or downgrade as appropriate. Air monitoring with the HNu should be performed during all future activities.

cc: EMG File
Document Control - NPMO/Annandale

Attachment: SEF.

001010

SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM

PAGE 1 OF 6

EPA WA NO. _____ REM II DOC. NO. _____

SITE Cavalcade - North & South EP/ REGION VI
 LOCATION Cavalcade and Muary St. - Houston, Texas EVALLATOR J. Gram

SITE DESCRIPTION Two sites, approximately 55 acres in size, consisted of wood treating operations for 21 years.
Suspected contaminants include: creosote, pentachlorophenol, and heavy metals. Presently
no surface contamination source exists.

SITE MAPS ATTACHED ☒ Project plan from 1983 CDM report.

BACKGROUND ENVIRONMENT All subsurface contamination.

AIR No contamination noted during site SURFACE WATER None observed.
survey on 1/1983

SOIL Extensive subsurface contamination exists GROUNDWATER Evidence of groundwater contamination
throughout the boundries of the site. observed during monitoring well sampling - 4/1983

ADDITIONAL HAZARDS ON-SITE Site currently used for a packing and trucking operations

INFORMATIONAL SOURCES USED CDM report - 7/83

001011

REM II DOC. NO.

POP DOCUMENT CONTROL NO. 100-86790-100

DESCRIPTION

PRELIMINARY SCHEDULE

A

Initial Site Characterization

1/16/85

001012

SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM

PAGE 3 OF 8

REM II DOC. NO.

[illegible]

SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM

PAGE 4 OF 6

REM II DOC. NO. _____

SITE PERSONNEL

SITE ACTIVITY Initial Site Characterization

PERSONNEL

NAME	SS NO	FIRM	REGION	LEVEL OF PROTECTION	CONTINGENCY	VERIFY
Jeffrey D. Gram	007 60 6115	CDM	NOR	D	C	(✓)
Richard S. Lawlis	462 78 3974	CDM	NOR	D	C	(✓)
						()
						()
						()
						()

PERSONNEL PROTECTIVE EQUIPMENT

VERIFY

Acid Resistant Coveralls	(✓)
Undergloves	(✓)
Steel Toe & Shank Boots	(✓)
Butyl Bootcovers	(✓)
Respirator - GMCH Cartridge - Contingency	()
Syran Suit - Contingency	(✓)
	()

FIELD MONITORING EQUIPMENT

VERIFY

H-Nu Photoanalyzer w/ 10.2 probe	(✓)
FID Hydrocarbon Analyzer	(✓)
Geiger Counter w/ Pancake probe	(✓)
	(✓)
	()
	()
	()

DECON

Roy F. Weston disposed of all expendables at an appropriate location.

001014

REM II DOC. NO. _____

CONTINGENCY CONTACTS

• DENOTES REQUIRED INFORMATION

AGENCY	CONTACT	PHONE NO.	AGENCY	CONTACT	PHONE NO.
• FIRE DEPARTMENT	City of Houston	(713) 227-2323	STATE POLICE		(713) 463-8261
POLICE DEPARTMENT	City of Houston Harris County	(713) 222-3131	F.A.A.		
HEALTH DEPARTMENT		(713) 342-8685	CIVIL DEFENSE		(713) 463-8261
• POISON CONTROL CENTER		(713) 654-1701	• ON SITE COORDINATOR	Mr. John Cochran	(214) 767-2630
• STATE ENVIRONMENTAL AGENCY	TDWR	(713) 479-5981	24-Hour Hotline	Agatha Corp.	1-(800)
• EPA REGIONAL OFFICE	John Cochran	(214) 767-2630			
• EPA ERT, ICOM					
• STATE SPILL CONTRACTOR					

MEDICAL EMERGENCY

NAME OF HOSPITAL Citizen General Hospital ADDRESS 7407 North Freeway - Houston PHONE NO. (713) 691-3531

NAME OF CONTACT _____ ADDRESS _____ PHONE NO. _____

MAP OR ROUTE TO HOSPITAL Take Cavalcade east to Route 59. Route 59 to 610 west. Route 610 west to North Freeway exit at Little York Street. Take right on Molly, Hospital on left.

TRAVEL TIME FROM SITE (MINUTES) 25 DISTANCE TO HOSPITAL (MILES) 10 NAME OF 24 HR. AMBULANCE SERVICE (713) 222-3434

001015

SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM

PAGE 6 OF 6

REM II DOC. NO. _____

SEF REVIEW

I have read, understood, and agreed with the information set forth in this Personnel Protection and Safety Evaluation Form (and attachments) and discussed in Presite Visit Health and Safety briefing.

SHSC SIGNATURE

DATE

RHSS SIGNATURE

DATE

COMMENTS:

COMMENTS:

SITE PERSONNEL

Jeffrey D. Gram

Richard S. Lawlis

SITE H & S BRIEFING

CONDUCTED AT On-Site

BY J.D. Gram

ON 1/16/85

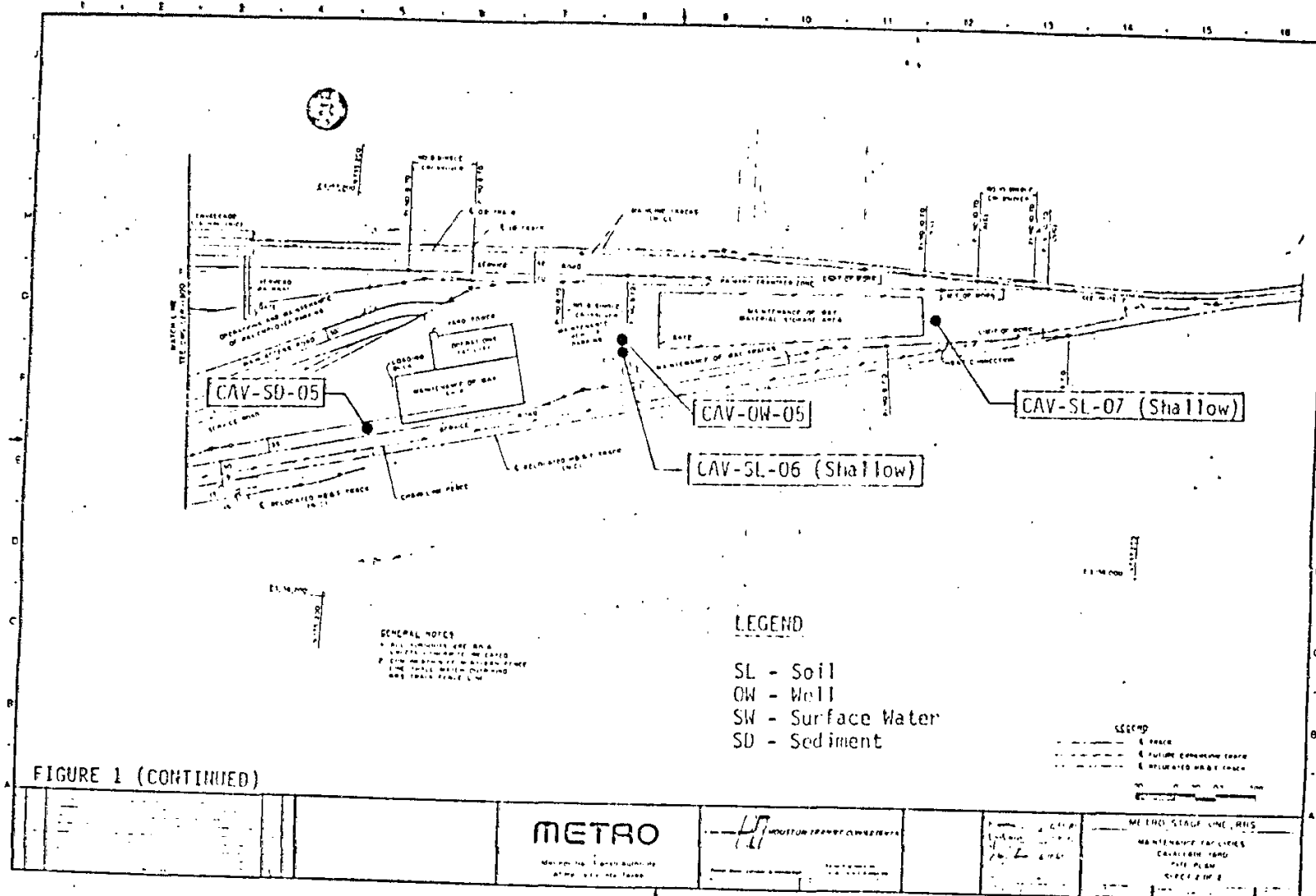
BRIEFING TOPICS Site History, Site Health & Safety
Issues, & Site Inspection Protocol

H.S.M. APPROVAL

DATE

REM II 9 & 10 INPUT BY 6

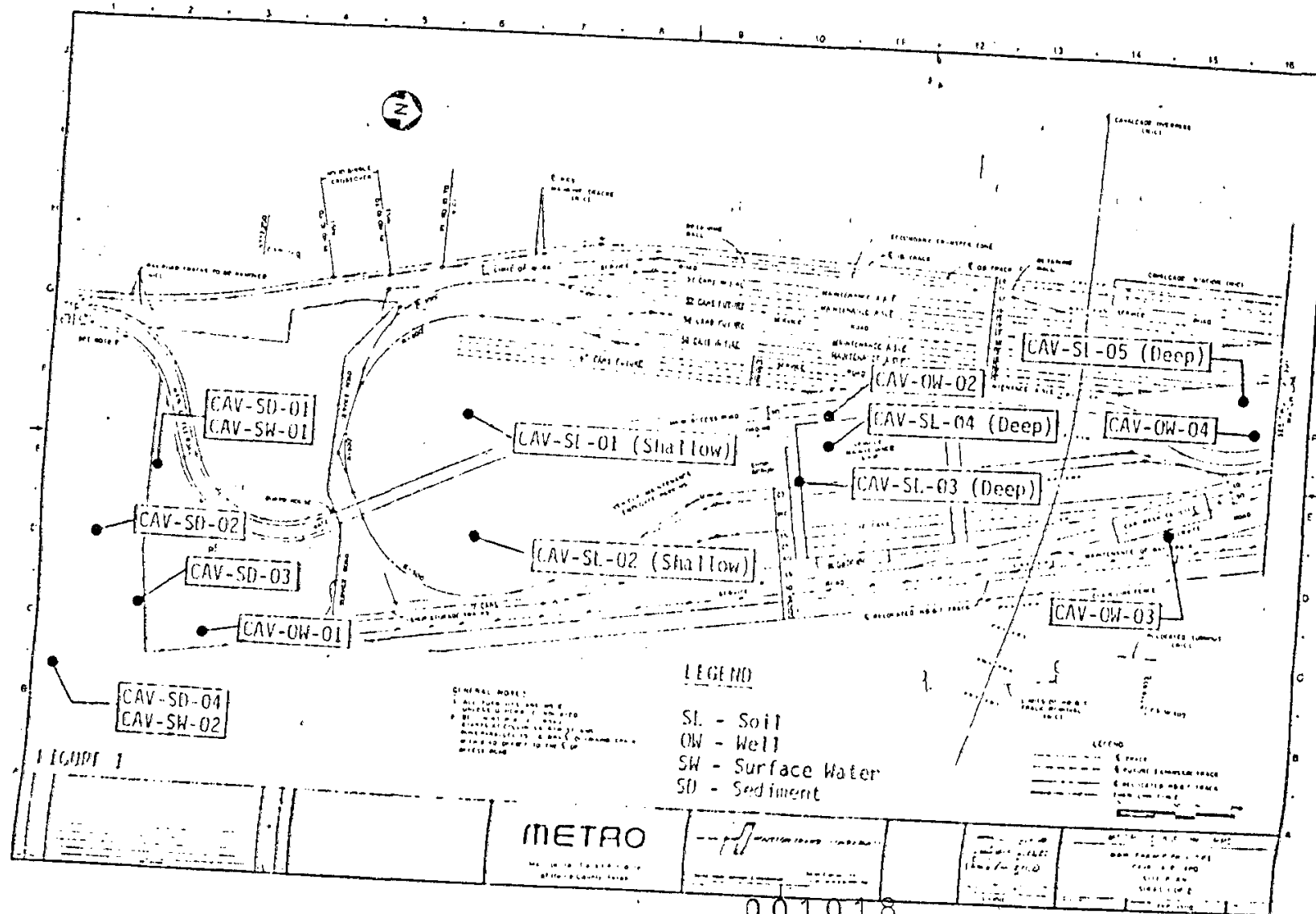
DATE



001017

CDM

ENVIRONMENTAL AND SOCIAL SCIENTISTS
STATION 1 & MANAGEMENT CONSULTANTS



CDM.

CDM CONSULTING ENGINEERS, INC.
1000 15th Street, N.W.
Washington, D.C. 20004

quired an 8 hour exposure at about 6000 ppm (35° C) to kill four or six rats. Signs of gross overexposure were varying degrees of ataxia, prostration, and respiratory distress followed by narcosis. Those that survived appeared to recover without significant signs of exposure.⁽¹⁾

Shell Chemical Corporation⁽²⁾ presents the following observations in respect to sensory responses reported by unconditioned personnel during or following 5-minute exposures to the vapor:

Threshold, odor	6 ppm
50% Threshold, eye irritation	30 ppm
50% Threshold, nose irritation	50 ppm

No incidents of illness caused by industrial handling of EAK have been reported. Workers may complain of odor

and transient eye irritation when handled in poorly ventilated areas when the concentration exceeds 25 ppm, but experience shows that transient responses do not lead to significant systemic effects.⁽¹⁾

Accordingly, the TLV of 25 ppm is recommended as a comfort level for unconditioned workers.⁽²⁾

References:

1. *Industrial Hygiene Bulletin* SC-57-59, Shell Chemical Corporation, NY (March 1958).
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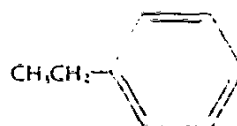
ETHYL BENZENE

Phenylethylene



TLV, 100 ppm (≈ 435 mg/m³)

STEL, 125 ppm (≈ 545 mg/m³)



Ethyl benzene is a colorless, flammable liquid with an aromatic odor. It has a molecular weight of 106.16, a specific gravity of 0.86256 at 25° C and a vapor pressure of 7.1 mm Hg at 20° C. The vapor density is 3.7 times that of air. "Saturated" air with the vapor at 26° C and 760 mm is 1.32%. It boils at 136.2° C and freezes at -45.01° C. The closed cup flash point is 63° F, autoignition temperature is 810° F and is a fire risk.⁽¹⁾ Ethyl benzene is only slightly soluble in water at 15° C (14 mg/100mL), but is miscible with alcohol and ether.

This compound is employed as a solvent and as an intermediate in the production of styrene.

Ethyl benzene toxicity is characterized by its irritancy to the skin and less markedly, to the mucous membranes. Repeated application of the liquid to the skin of rabbits causes reddening and some excoriation and blistering.⁽²⁾ Oettel⁽³⁾ characterized ethyl benzene as the most severe irritant of the benzene series.

On the eyes and nose, the vapor at 5000 ppm causes intolerable irritation; at 2000 ppm, eye irritation and lacrimation are immediate and severe, and are accompanied by moderate nasal irritation, decreasing somewhat in several minutes; at 1000 ppm, irritation and tearing, but tolerance develops rapidly; and at 200 ppm, the vapor has a transient irritant on human eyes.⁽¹⁾

Like benzene, its acute toxicity is low; the dose fatal to guinea pigs in a few minutes was 10,000 ppm⁽⁴⁾ and 5000 ppm dangerous to life in 30 to 60 minutes; animals dying

from exposure had intense congestion and edema of the lungs, and generalized visceral hyperemia. The narcotic dose for animals was 10,000 ppm, reached in 18 minutes preceded by vertigo, unsteadiness and ataxia.

Chronic inhalation exposure of guinea pigs, monkeys, rabbits and rats at concentrations from 400 ppm to 2,200 ppm, seven to eight hours, day, five days/week for as long as six months produced no effects in all species except the rat, which showed a slight increase in the weights of the kidneys and livers, on the average, for those exposed at 400 ppm for 186 days. The investigators concluded that 400 ppm was the beginning effect level for chronic inhalation of the vapor.⁽¹⁾

It is apparent that, as no systemic effects can be expected at levels producing distinctly disagreeable skin and eye irritation, the TLV must be based on the latter effects. For the prevention of disagreeable irritation a TLV of 100 ppm and a STEL of 125 ppm are recommended.

Other recommendations: Czechoslovakia (1976) 45 ppm; Poland (1975) 25 ppm.

References:

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skier et al.¹² reported that 25% of 68 workers handling chloroform in a chemical plant had enlarged livers. The lengths of employment were between 1 and 4 years. Concentrations of chloroform in air ranged from 10 to 200 ppm.

In the view of recent reports on carcinogenicity and embryotoxicity of chloroform, the Committee recommendation for TLV chloroform is 10 ppm as TWA and classification as an Industrial Substance Suspect of Carcinogenic Potential for Man (A2). A concentration of 10 ppm is one fifth of the concentration at which organ injury was observed and is half of the concentration which would be derived comparing the toxicity of other organic solvents.¹³ NIOSH recommended in 1974 a TLV 10 ppm as TWA and in 1976 lowered the value to 2 ppm because of suspected carcinogenic potential of chloroform.¹⁴

Foreign Industrial Air Standards (taken from Reference 12): Bulgaria, 10 ppm; Czechoslovakia, 10 ppm; for brief exposures, 30 ppm; Finland, 30 ppm; Hungary, 3 ppm; for brief exposures, 20 ppm; Japan, 50 ppm; Poland, 10 ppm; Rumania, 10 ppm; Yugoslavia, 30 ppm; West Germany, 10 ppm (1978).

References:

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8. Roe, F.J.C.: *Prelim. Rept. of Long-Term Tests of Chloroform in Mice, Rats and Dogs, Soc. of Tox. Ann. Meetings, Atlanta, GA* (March 18, 1976).
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Bis(CHLOROMETHYL) ETHER

bisCME



TLV, 0.001 ppm ($\approx 0.005 \text{ mg/m}^3$), Appendix A1a — Recognized Carcinogen

The chloromethyl ethers, bischloromethyl and chloromethyl ether (CME), are highly reactive, colorless liquids with a suffocating odor and high vapor pressures. bisCME has a molecular weight of 114.96, a specific gravity of 1.315 at 20°C, a melting point of -41.5°C and a boiling point of 104°C. It is an inadvertent compound generated in the production and use of CME, which, in the presence of either hydrogen or hydroxyl ions and traces of water, disproportionates to aldehydes and methanol, which in turn recombine to form bisCME. It is soluble in all proportions in alcohol and ether, but is decomposed by water into hydrogen chloride and formaldehyde.

BisCME is no longer used for chloromethylation in industry, but is used as the monitoring indicator for CME, because of its greater stability in workroom air, and as an intermediate in anionic exchange strong-base resins of the quaternary ammonium type.

The carcinogenic potency of bisCME is greater than CME. Attention was first called to the alpha-halo-ethers as alkylating carcinogens by Van Duuren et al.¹⁵ bisCME was found to be a potent alkylating carcinogen for mouse skin, more potent than either the beta-lactones (β -propiolactone) or epoxides (1,2-epoxybutane). Subsequently, bisCME was reported to be a highly potent inducer of tumors in the respiratory tract in mice¹⁶ and rats.¹⁷ Increased num-

bers of pulmonary adenomas occurred in mice upon repeated daily exposures to bisCME at 1 ppm, and squamous cell carcinomas of the lung and esthioneuroepithelioma of the olfactory epithelium occurred in rats following similar conditions of inhalation exposure at a reported 0.1 ppm bisCME.

That bisCME could be carcinogenic for man was first observed in 1964 and 1965 following the deaths from lung cancer of two relatively young employees, aged 48 and 35 years respectively, who had worked in chloromethylation operations.¹⁸ Later, in 1967, a 39-year old male chemist who had worked in both the research laboratory and pilot plant during the period 1951 to 1965 died of lung cancer. A fourth lung cancer death occurred in 1971 in a 32-year old employee who was first employed two years earlier. This employee had, however, reportedly worked in the warehouse and tank farm and thus was relatively removed from direct contact with chloromethyl ether operations. Two additional employees are currently alive, but with lung cancer: one, age 60, had worked in the research and development laboratory, the other, had worked for 13 years in the warehouse and in the steam-tube drier operation in the ion-exchange department. Although five of the six lung cancer employees were considered tobacco smokers, this distribution of smokers is not too dissimilar from that of the general population. This fact, coupled with relatively high incidence of lung cancer, (6 of approximately 100 employees), the relatively youthful age when the cancers appeared, and the demonstrated potency of the chloromethyl ethers for animals¹⁵ make these ethers highly suspicious of being carcinogenic for man.

Further animal experimental evidence of the potent carcinogenicity of bisCME was provided in a report¹⁹ of the finding that 98 of 111 rats had gross or microscopic

exposure standard, insofar as the TLV can be defined as such a standard. There is little evidence that exposure to benzene at concentrations below 25 ppm causes blood dyscrasias of any kind. Setting the TLV at 10 ppm as a time-weighted average, provides an added margin of safety.

If the standard is to be set at the lowest practicable detectable limit, it is the opinion of some members of the Committee that a value lower than 1 ppm should be selected. In the absence of interfering substances benzene vapor can be measured with reasonable accuracy in concentrations at least as low as 0.1 ppm; in the presence of certain interferences, it may be difficult to achieve the prescribed accuracy and reliability even at concentrations somewhat above 1 ppm.

Because the effects the TLV is designed to prevent are chronic in nature, a ceiling designation is not appropriate and a STEL of 25 ppm is recommended.

Other recommendations: ANSI (1969) 10 ppm; Czechoslovakia (1969) 16 ppm; USSR (1972) 16 ppm; DDR (1973) 16 ppm; Sweden (1975) 10 ppm; BRD (1974) 0 ppm (treats as carcinogen).

References:

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31. NIOSH: *Criteria for a Recommended Standard for Occupational Exposure to Benzene* (1974).
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including leukemia, was found to be higher than in the general population among certain groups of rubber workers. Monson and Nakano⁽¹¹⁾ found 55 cases of leukemia vs. 43 expected, among rubber workers. It was noted that benzene has been used extensively in the rubber industry but is no longer employed, although it is a contaminant of extensively used naphtha solvents. The degree of exposure to benzene in the rubber industry during the first half of the 1940-1950 decade may well have been excessive. Wilson⁽¹²⁾ has noted deaths and blood abnormalities among workers in the rubber industry during the war years who were exposed, on the average, to concentrations of benzene vapor of 100 ppm. Neither Monson-Nakano or other authors or similar papers quoted in the NIOSH update mention whether or not aplastic anemia or other blood dyscrasias, apart from leukemia, occurred in the groups of workers that were studied.

Nevertheless OSHA, in 1977, issued an Emergency Temporary Standard (ETS) establishing a TWA limit of 1 ppm for benzene vapor (Enforcement of this standard was voided by the courts). Much of the evidence substantiating this action was the same as that quoted in the NIOSH update. However, one additional paper was cited by Infante et al.⁽¹³⁾ in which nine leukemia deaths were reported from two rubber tire casting plants where benzene vapor concentrations allegedly ranged from 0 to 15 ppm. This report was critically examined in OSHA hearings on a permanent standard, with essentially the same provisions as the ETS, which were held during the summer of 1977. The data on benzene exposure in the two plants in question, especially during the first part of the ten year employment period (1940 to 1950) covered by the study, were found to be incomplete, unreliable and contradictory. Even in 1976 a NIOSH report of one of the plants involved, or its successor, showed concentrations in excess of 15 ppm at several locations.⁽¹⁴⁾ A study by Harris et al.⁽¹⁵⁾ in 1973 and 1974 revealed similar findings, although the overall average of all sample results was slightly above 1 ppm. During the period 1940 to 1945 or so, when many of the involved workers were employed, the permissible concentration for benzene exposure (ASA standard) was 100 ppm. In common with the papers cited by the NIOSH update, no information on other blood abnormalities was given in the Infante report.

Epidemiologic studies of workers exposed to measured low concentrations of benzene vapor have yielded negative or inconclusive results. Thorpe⁽¹⁶⁾ after studying the occurrence of leukemia in a population of 38,000 workers in a variety of European petroleum and petrochemical operations, some of whom were exposed at levels of benzene that occasionally reached 20 ppm over a period of ten years, found that deaths from leukemia "were not abnormal" for the countries involved (18 vs. 23.23 expected).

Retrospective studies of employees of a large chemical company, exposed for many years to benzene, mostly at low levels, revealed no excess mortality.^(17,18) A cohort of 594 workmen were divided into four exposure groups: very low exposures, less than 2 ppm as time weighted average (TWA); low exposures, 2-9 ppm; moderate exposures, 9-24 ppm; and high exposures, above 25 ppm. In many areas there was exposure to other chemicals as well as to benzene. The duration of exposure was also divided into four groups, with 186 workers having in excess of 20 years.

Of 102 deaths, two were due to anemia, two to leukemia and one had leukemia as a complication. Of these five cases, only one, an autopsy-confirmed pernicious anemia, involved a previous exposure to benzene of significance, 5520 ppm months. The other anemia death, diagnosed as being of the aplastic type, was of a worker with 453 ppm months of benzene exposure. Two of the leukemia cases involved exposures of 545 and 305 ppm months, respectively, while the third was of a worker with only 18 ppm months benzene exposure.

To put these exposure data in perspective, three of the deceased workers had had exposures to benzene equivalent to 40 years employment in concentrations slightly above or below 1 ppm; the exposure of the fourth, if spread over 30 years, would have been at a concentration of 0.05 ppm.

The predicted deaths from anemia and leukemia were 0.2 and 1 respectively. The fact that, apart from the pernicious anemia death, there appeared to have been no dose response relationship, apparently led to the conclusion of the authors that "no mortality findings directly attributable to benzene exposure were observed".

The NIOSH update mentions the consistent observations of chromosomal aberrations associated with benzene exposure, but further comments that the implications of these findings with respect to benzene leukemia are still not clear. The possibility of a chromosomal instability acting as a stimulus for a latent leukemogenic virus has been speculated upon.⁽¹⁹⁾ This question was discussed at some length at the International Workshop on the Toxicology of Benzene, held in Paris in November 1976. Tough⁽²⁰⁾ had previously reported that marked aberrations were found only in plants where concentrations of benzene vapor were believed to be between 25 and 250 ppm, and that no significant changes were observed at 12 ppm. Fornace⁽²¹⁾ however, stated that there had been a few positive, as well as negative, reports at levels between 5 and 25 ppm. The consensus of opinion was that the significance of the finding of increased chromosome aberrations for the occurrence of benzene leukemia was still not clear. Maugeri and Pollini⁽²²⁾ reported that among Italian shoe workers "almost all the cases of haemopathy due to benzol which lead to death show features of terminal leukemia... and (the leukemias) were always preceded by aplastic conditions".

Opinions of the workshop participants relative to the appropriate TLV for benzene were varied. The final recommendation was to retain 10 ppm as a permissible TWA which must not be exceeded, but it was also specified that benzene should not be employed when substitute materials were available.

DeGowin's report⁽²³⁾ of a case of leukemia following an apparent benzene-induced aplastic anemia contains a discussion which implies that there is evidence that aplastic anemia *per se* may lead to leukemia, and that delayed cases of this disease are not confined to aplastic anemia due to benzene.

It is the opinion of the Committee that the characterization of benzene as a leukemogen, by NIOSH, is, in essence, valid, although benzene may be what Truhaut has described as a "secondary carcinogen".⁽²⁴⁾ An A2 notation should be applied to benzene in the TLV listings.

On the other hand, the Committee does not agree with the NIOSH recommendation of 1 ppm as an occupational

numerous organic chemicals, it is found in gasoline from trace amounts to as much as 30% concentration in some countries.

As an acute poison benzene produces narcotic effects comparable to those of toluene; it is a more potent narcotic than the alkanes or naphthenes of similar boiling points. But the effect of chronic exposure to this compound is by far the most serious disease caused by any of the common hydrocarbon solvents. Its action on the bone marrow may result in detectable alterations and, in some instances, aplastic anemia. The reported LD₅₀ orally in young adult rats is 3.8 mL/kg.⁽¹⁾

It is unique among hydrocarbons as a myelotoxicant.⁽²⁾ More than 140 fatal cases of benzene poisoning had been recorded prior to 1959.⁽³⁾ Vigliani and Saita⁽⁴⁾ listed 26 deaths from chronic benzene poisoning in two provinces in Italy between 1960 and 1963. Eleven of these were diagnosed as leukemia, which may develop several years after cessation of exposure to benzene.

Most deaths from benzene have resulted from exposures of the order of 200 ppm or more. In a few instances concentrations of 1000 or even 2000 ppm have been recorded in workplaces where deaths occurred. Some of these are: Legge,⁽⁵⁾ 210 to 1050 ppm; Greenburg,⁽⁶⁾ 70 to 1800 ppm, with over half above 200; Bowditch,⁽⁷⁾ 100 to 200+ measured, one leukemia case described by Hunter⁽⁸⁾ and Maury⁽⁹⁾ six years after exposure at over 200 ppm; Greenburg,⁽⁶⁾ 25 to 1000 ppm in four rooms; Helmer,⁽¹⁰⁾ 140 to 200 ppm after improvements; Saviahtir,⁽¹¹⁾ 318, 433 and 470 ppm; Koziova,⁽¹²⁾ 47 to 310 ppm; Vigliani,⁽⁴⁾ 190 to 660 ppm, after four years death from leukemia; Juzwiak,⁽¹³⁾ 31 to 156 ppm; Akoy,⁽¹⁴⁾ 150 to 650 ppm, and 210 to 650 ppm;⁽¹⁵⁾ 26 patients with acute leukemia or preleukemia; Ikeda,⁽¹⁶⁾ 100 to 600 ppm, 7 deaths, all females, none from leukemia.

Winslow,⁽¹⁷⁾ however, reported blood changes in workers where concentrations of benzene vapor below 100 ppm were found. Hermann and Ford⁽¹⁸⁾ found one death and three cases with blood changes where air analysis for benzene showed a concentration of 105 ppm. Wilson⁽¹⁹⁾ reported three fatal cases in a plant where the average concentration of benzene vapor was 100 ppm. In a fifth room, associated with benzene poisoning, Greenburg⁽⁶⁾ found 11 to 57 ppm. So far as can be determined the lowest measured concentration of benzene vapor associated with a fatal case of benzene intoxication (due to aplastic anemia) was the 80 ppm reported by Hardy and Elkins in 1948,⁽²⁰⁾ in a plant where repeated air analyses were made, and a number of other workers showed some blood abnormalities.

Blaney⁽²¹⁾ found little evidence of benzene intoxication in a group of 90 workers regularly exposed to benzene for about 13 years. Concentrations were generally low, but urinary phenol measurements indicated some exposures of the order of 25 ppm.⁽²²⁾ A followup several years later showed no evidence of persisting blood dyscrasias. No cases of leukemia are known to have occurred in this group of workers. Pagnotto *et al.*⁽²³⁾ found workers in rubber spreading operations involving naphtha with a relatively high benzene content exposed to benzene in concentrations which were for the most part between 6 and 25 ppm. A number of blood studies showed a few abnormalities but only two were serious to warrant special consideration. In one case the possibility of leukemia was raised, but on being removed from his job and given iron therapy

the worker recovered. Because of several job changes his benzene exposure could not be reliably estimated.

The other worker was in a group studied intensively over a period of several years by Pagnotto.⁽²³⁾ He had a red count below four million, a hemoglobin below twelve grams and suffered from nose bleeds. His benzene exposure, as estimated from several urinary phenol determinations, was to about 40 ppm. After his exposure to benzene was terminated, his blood picture gradually returned to normal. The 38 workers in this plant were followed up for 15 years after the use of naphtha containing benzene was discontinued. None showed any signs of permanent blood abnormalities. There were three deaths, none being from leukemia. It was concluded that 25 ppm of benzene vapor is safe for most workers, but that since the margin of safety is small, a TLV of 10 ppm was recommended.⁽²⁴⁾ Elkins⁽²⁰⁾ in a summary of the findings in the rubber spreading industry, came to a similar conclusion.

These conclusions were consistent with those of Fuchs⁽²⁵⁾ in 1969, who found variations in the blood pictures of three workers but did not consider that the changes were proved to result from their benzene exposures of 19, 28 and 43 ppm, respectively. He also stated that he could find no data in the literature on proved benzene poisoning in concentrations below 16 ppm, nor could he find any Soviet report which cited reasons for decreasing the Russian MAC to 0 ppm.

Two investigators have studied the effects on rats of exposures at relatively low levels of benzene vapor extended periods. Deichmann *et al.*⁽²⁶⁾ found that after 5 to 8 weeks of 5 hour/day, 5 days/week exposure at 44 and 47 ppm, rats developed a moderate degree of leukopenia, but that none resulted from 15 to 31 ppm. Nau *et al.*⁽²⁷⁾ found a decrease in the white blood cell counts of rats following 756 hours of exposure at 50 ppm of benzene on a schedule of 8 hours/day, 5 days/week. Reduced amounts of DNA in the white cells, a depression in myelocytic activity and an increase in the relative numbers of red cell precursors in the bone marrow were also observed.

There have been numerous reviews of the literature of benzene intoxication. Noteworthy are those of the National Academy of Sciences in 1975⁽²⁸⁾ and the NIOSH criteria document on benzene, published in 1974.⁽²⁹⁾ As a result of this extremely thorough review, NIOSH recommended a workplace time weighted average standard of 10 ppm, with a ceiling of 25 ppm.

In 1976, however, NIOSH issued a revised recommendation for an occupational exposure standard for benzene.⁽³⁰⁾ The key to this recommendation is the statement in the introduction that "Because it is not at present possible to establish a safe exposure level for a carcinogen, the NIOSH recommendation is to restrict exposure to very low levels which can still be reliably measured in the workplace." A number of references are given, primarily to support the characterization of benzene as a carcinogen (leukemogen). Thus most relate to leukemia cases associated with heavy benzene exposures, either measured or inferred from association with numerous cases of aplastic anemia or other blood dyscrasias. Others are epidemiologic studies on cancer in which no evidence of the degree, or even fact, of benzene exposure is cited. Thus in at least two of these papers,^(31,32) the word "benzene" does not appear. In these and other papers the incidence of various types of cancer,

BENOMYL

Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate;
Benlate

$C_{14}H_{18}N_4O_3$

TLV, 10 mg/m³

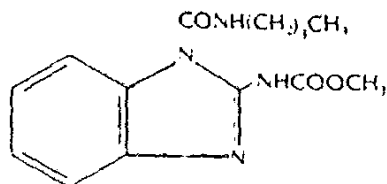
STEL, 15 mg/m³

Benomyl is a white crystalline solid, which has a molecular weight of 290.32. It decomposes without melting and has a negligible vapor pressure, indicating exposure would be in particulate form. Very slightly soluble in water, it is soluble in xylene, acetone, dimethylformamide and chloroform.⁽¹⁾ Fluorometric and colorimetric⁽²⁾ and liquid chromatographic⁽³⁾ procedures for determining residues of benomyl have been published.

Benomyl is the common name for this fungicide and ascaricide.

The acute oral LD₅₀ for the rat is $\geq 10,000$ mg/kg. The acute skin absorption LD₅₀ for the rabbit is $\geq 10,000$ mg/kg. Application to the shaved intact skin of ten male guinea pigs, at each level as aqueous suspensions containing 5, 12.5 and 25% benomyl as the active ingredient in a 50% wettable powder, resulted in negligible irritation. One of ten guinea pigs had mild erythema two days after application at the high rate. All guinea pigs at the two lower rates and in a control showed no irritation after two days.⁽⁴⁾ Instillation into the eyes of rabbits of 10 mg of dry 50% powder or 0.1 ml of 10% suspension in mineral oil caused only temporary mild conjunctival irritation.⁽⁵⁾ The acute inhalation LC₅₀ is ≥ 2000 mg/m³ (≥ 2 mg/L) for rat⁽⁶⁾ and is equivalent to ≥ 825 mg/m³ (≥ 0.825 mg/L) for dog⁽⁴⁾ for four-hour exposures. Histologically, there was reduction of spermatogenic activity in some animals. With regard to this activity, no-effect levels for benomyl for four-hour exposures are equivalent to $\geq 100 \leq 410$ mg/m³ ($\geq 0.1 \leq 0.41$ mg/L) for the rat and $\geq 325 \leq 825$ mg/m³ ($\geq 0.325 \leq 0.825$ mg/L) for the dog. Additionally fifteen four-hour inhalation exposures at the equivalent of 100 mg/m³ (0.1 mg/L) of benomyl over a period of three weeks produced no clinical or histopathologic indication of accumulative effects in the rat.⁽⁴⁾

A low order of toxicity has been found in chronic studies. In two-year feeding studies no-effect levels in the diet are 2500 ppm (0.25%) for rats (highest level fed) and 500



ppm (0.05%) for dogs. Pesticide residue tolerances have been established in many food crops. They are as high as 15 ppm for stone fruits and food additive tolerances are as high as 50 ppm for raisins.⁽¹⁾ In a three-generation rat reproduction study no compound-related reproduction or lactation differences were observed among control and test groups even at 2500 ppm (0.25%), the highest dietary level fed. In a teratogenic study in rat neither the outcome of pregnancy nor embryonal development was affected even at 5000 ppm (0.50%), the highest dietary level fed. In a dominant lethal mutagenic study in the rat, benomyl was not mutagenic at 2500 ppm (0.25%), the highest dietary level fed.⁽⁷⁾

Gardiner et al.⁽⁸⁾ showed that rat and dog eliminated $\geq 99\%$ of single, oral doses of ¹⁴C benomyl via the urine and feces within 72 hours. The major metabolite was methyl 5-hydroxy-2-benzimidazole-carbamate which was present in the urine as glucuronide and/or sulfate conjugates. Residue data on dog and rat tissues from two-year chronic feeding studies demonstrated that benomyl and its metabolites do not accumulate in animal tissues.

In view of the low order of acute and chronic toxicity, the TLV of 10 mg/m³ and the STEL of 15 mg/m³ appear appropriate.

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BENZENE

C_6H_6

TLV, 10 ppm (≈ 30 mg/m³), Appendix A2 — Suspected Carcinogen

STEL, 25 ppm (≈ 75 mg/m³), Appendix A2

Benzene is a colorless, non-polar liquid, with an odor characteristic of aromatic hydrocarbons. It has a molecular weight of 78.11, a boiling point of 80.1° C, a melting point of 5.5° C, a vapor pressure of 75 mm Hg at 20° C and a

specific gravity of 0.87865 at the same temperature. Benzene has a flash point of -11.1° C (closed cup, 12° F), making it a dangerous fire hazard. It was formerly derived almost exclusively by distillation of coal tar, but now comes primarily from petroleum, either by extraction or by dealkylation of toluene. Benzene is slightly soluble in water, but soluble in all proportions in alcohol, acetone and ether.

At one time benzene was an important solvent, especially for rubber, as a diluent in lacquers, and in paint removers. At present such uses are minimal; most benzene is consumed in the chemical industry, as a raw material for

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METHYLENE CHLORIDE

Dichloromethane



TLV, 100 ppm ($\approx 360 \text{ mg/m}^3$)

STEL, 500 ppm ($\approx 1700 \text{ mg/m}^3$)

Methylene chloride is a colorless volatile liquid soluble in water to only 1% by weight, but completely miscible with most organic solvents. It has a sweetish odor, like most chlorinated hydrocarbons. The molecular weight is 84.94, a specific gravity is 1.335, boiling point is 40°C and it solidifies at -95°C . With its high vapor pressure (375 mm Hg at room temperature, 23.5°C) substantial concentrations of vapor are readily achieved whenever methylene chloride is spilled or spread out over a large surface, even in a space that is not closely confined. It is non-flammable by standard tests, but will burn in extreme conditions.

Methylene chloride is widely used in paint removers as a solvent for plastics, as a degreasing agent, in propellant mixtures for aerosol sprays and as a blowing agent in foams. The odor is not a good indication of exposure since concentrations of 100 ppm reportedly are not highly perceptible.

Liquid methylene chloride is painful and irritating if splashed in the eyes or if confined on the skin by gloves, clothing or paint remover formulations. A burn can result if it is not promptly removed from the eyes and skin. The acute oral LD_{50} for rats is about 2000 mg/kg.

According to Lehmann and Flury,¹ slight narcosis occurs at 4000 to 6000 ppm in several species of animals. The fatal concentration for seven hours exposure is given by many authorities as about 75000 ppm.² Rats exposed 75 days (8 hours a day) at 1500 ppm showed slight liver changes which were not found at 50 days. Cats exposed four to eight days at 7200 ppm for four weeks were found to have kidney and liver changes. Heppel and associates³ found that daily seven-hour exposures at 5000 ppm for six months had no discernible effect on dogs and rabbits and only reduction in the rate of growth of guinea pigs. At 10000 ppm, four hours a day for seven and one-half weeks dogs and guinea pigs, but not monkeys, rabbits or rats developed liver injury. Moskowitz and Shapiro⁴ reported four cases of poisoning with one fatality apparently due to narcotic action. Collier⁵ reported two cases of poisoning in painters who suffered from headache, giddiness, stupor, irritability, numbness and tingling in the limbs. Kuzelova and Vlasak⁶ noted complaints of headache, fatigue and irritation of the eyes and respiratory passages by workers exposed at concentrations up to 5000 ppm. Neurasthenic disorders were found in 50%, and digestive disturbances in 30% of the persons exposed. Three acute poisonings, one involving loss of consciousness, were recorded without serious after-effects.

Weiss⁸ stated that a chemist after a year's exposure developed toxic encephalosis with acoustical and optical delusions and hallucinations. Concentrations frequently exceeded 500 ppm, values of 650 ppm, 800 ppm and near the floor, 3600 ppm were noted.

Golubovski and Kamchatnova⁹ found liver disease in workers exposed to methylene chloride and methanol which they attributed to the former. Exposure concentrations were not reported.

In the early 1940's methylene chloride was considered the least toxic of the chlorinated hydrocarbon solvents when a safe industrial air limit of 500 ppm was proposed by Heppel et al.¹⁰ and later adopted by the TLV Committee as protective enough to prevent any significant narcotic effects or liver injury.

Subsequently, Stewart et al.¹¹ reported that significant quantities of carbon monoxide and carboxyhemoglobin were produced in humans receiving single exposures at 500-1000 ppm of methylene chloride. The carboxyhemoglobin concentrations reported by Stewart approximated those considered objectionable if due to inhalation of carbon monoxide.

More extensive examination of CO production from methylene chloride was later reported by the same investigators.¹² Human volunteers exposed to methylene chloride at 1000 ppm for two hours (2000 ppm-hours), one-half of the CL permitted for an 8-hour exposure at 500 ppm, resulted in carboxyhemoglobin levels in excess of those permitted in industry from exposure to CO alone.

This finding of the body's capacity to metabolize methylene chloride to CO was confirmed by Ratnev, Wegman and Elkins¹³ in a small group of workers exposed to 180 to 200 ppm methylene chloride. Such daily repeated exposures resulted in equilibrium blood concentrations of carboxyhemoglobin of 4% that decreased to half that value by next day's start of work. The differential decrement in percent carboxyhemoglobin of 4.5% from a day's exposure at 180 to 200 ppm of methylene chloride is approximately the same as that developed from a daily exposure to CO at its TLV of 50 ppm.

DiVincenzo¹⁴ found that humans exposed to 100 ppm methylene chloride for 8 hours had a carboxyhemoglobin (COHb) value of $3.22\% \pm 0.22\%$, whereas an 8-hour exposure at 150 ppm produced $5.39\% \pm 0.06\%$ level and an 8-hour exposure at 200 ppm resulted in COHb level of $6.63\% \pm 0.63\%$.

In an extensive study several healthy adults of both sexes were exposed from 2-10 times to methylene chloride vapor concentrations of 0.50, 100, 250 or 500 ppm for periods of 1, 3 and 7.5 hours in a controlled environment chamber. These studies were designed to simulate the type of exposures encountered in the industrial setting and consisted of both steady, non-fluctuating vapor concentrations. Exposure resulted in a prompt elevation of carboxyhemoglobin. The elevation persisted longer than COHb from CO alone since metabolism of the absorbed methy-

ene chloride continued after exposure ceased. This solvent-induced COHb is apparently added to the body burden of carbon monoxide derived from other sources.

This study corroborated previous single exposure studies in that no deleterious effects upon the health or performance of healthy adults could be detected when they were repeatedly exposed to 250 ppm or less for 7.5 hours per day, five days per week for 2 weeks, or in the case of the male subjects, to 500 ppm on two consecutive days. Among the parameters studied were complete blood count, clinical chemistry (SMA 12), EKG, serum triglycerides, blood pressure, subjective signs and symptoms, urinalysis (Combitox), urinary urobilinogen, neurological tests, EEG, visual evoked response, pulmonary function and cognitive alertness, time estimation, coordination, arithmetic and inspection tests.

The increase in COHb was related to the magnitude of the vapor exposure. Both duration of exposure and vapor concentration were factors. Seven and one-half hour exposures to concentrations as low as 100 ppm for 5 days resulted in COHb elevations about 5 percent in nonsmokers. The odor was not objectionable at 250 ppm and many subjects could not detect it at 50 or 100 ppm.

Since the toxic effects of methylene chloride are due in part to its conversion to carbon monoxide, they would presumably be augmented by the presence of carbon monoxide in the air. Roder *et al.* found the effects of CO and the COHb from methylene chloride to be additive in 3-hour exposure tests with rats. Therefore, whenever there is a combined exposure to the vapors of methylene chloride and carbon monoxide, the appropriate equation for mixtures should be used in determining whether or not the exposure is acceptable.

A time-weighted average (TWA) of 100 ppm is recommended for methylene chloride in the absence of occupational exposure to carbon monoxide. This recommendation is based upon experimental data obtained from non-smoking males at rest, and should keep COHb levels well below 5 percent. A STEL of 500 ppm is recommended since data indicate that neither undesirable CNS responses nor COHb values are likely to occur with such exposures to methylene chloride (11). Concurrent exposure to other sources of carbon monoxide or physical activity will require assessment of the overall exposure and adjustment for the combined effect.

Other recommendations: NIOSH (1976) 75 ppm; West Germany (1979) and Elkins (1959) 200 ppm; ANSI (1964) 500 ppm; USSR (1970) 15 ppm; East Germany (1973), Romania (1975), Yugoslavia (1971) and Czechoslovakia (1976) 120 ppm; Sweden (1974) 100 ppm; others 200 or 250 ppm.

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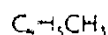
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TOLUENE

Toluol



Skin

TLV, 100 ppm (\approx 375 mg/m³)

STEL, 150 ppm (\approx 560 mg/m³)

Toluene is a colorless liquid with a typical aromatic hydrocarbon odor. Its molecular weight and specific gravity are 92.13 and 0.866, respectively. The boiling point is 110.7° C and solidifies at -95° C. At 25° C, the vapor pressure is 28 mm Hg. The closed cup flash point is 40° F. It is insoluble in water, but miscible with most organic solvents.

Formerly derived solely from coal tar, toluene is now obtained chiefly from petroleum, and is present in gasoline and many petroleum solvents. It is used as a solvent in paints and coatings, for rubber, oils, resins, etc., as a raw material for the manufacture of benzene and a host of other chemicals, including TNT, TDI, and ingredients of detergents, dyes and drugs.

Because of its wide industrial use and chemical similarity to benzene, the literature of industrial toxicology and industrial medicine, particularly the latter, record numerous investigations of the toxic effects of toluene. According to Patty,¹ the concentrations of toluene and benzene required to cause prostration of mice are apparently 3000 ppm and 4700 ppm, respectively. Death from acute poisoning results from 10,000 ppm toluene compared with 14,000 ppm of benzene. Several incidents of workers being overcome by toluene vapor, usually in confined spaces, have been reported. Longley and co-workers² describe such an event aboard ship where 26 men were overcome. There were no deaths or serious aftereffects. No irritation of eyes or respiratory passages was observed.

From the standpoint of chronic poisoning, toluene does not cause the severe injury to the bone marrow characteristic of benzene poisoning. Gerarde³ stated that the myelotoxicity of benzene was completely absent in toluene and other alkyl derivatives of benzene. Von Oettingen *et al*⁴ found that exposure of rats at 2500 to 5000 ppm of toluene caused a temporary decrease in the white-cell count, but no evidence of injury to blood-forming organs or liver. Greenburg and co-workers⁵ studied a group of painters exposed to toluene in concentrations ranging from 100 to 1100 ppm. Their findings included enlargement of the liver, macrocytosis, moderate decrease in erythrocyte count and absolute lymphocytosis, but no leukopenia.

Wilson⁶ found that among workers exposed at less than 200 ppm of toluene there were some complaints of headache, lassitude and nausea, but physical findings were essentially negative. At concentrations between 200 and 500 ppm impairment of coordination, momentary loss of memory and anorexia were also present. Between 500 and 1500 ppm palpitation, extreme weakness, pronounced loss

of coordination and impairment of reaction time were noted. The red cell count fell in many instances, and there were two cases of aplastic anemia, in which recovery followed intensive hospital treatment. A later comment by Wilson⁷ however, suggests that he did not rule out the possibility that some of the above effects were due to a benzene impurity in the toluene used.

According to Fairhall,⁸ severe exposure to toluene may result in a pronounced drop in the red count and partial destruction of the blood-forming elements of the bone marrow. However, Gerarde⁹ stated that extensive animal studies clearly indicate that toluene is not a bone marrow poison. While there have been occasional reports of aplastic anemia attributed to toluene,¹⁰ in some instances the presence of benzene was not precluded, and there have been no "epidemics" of this disease among toluene workers comparable to those which have resulted from benzene. Powars¹¹ reported six cases of aplastic anemia, one of them fatal, among glue sniffers. Although toluene was the solvent chiefly used, no analysis was given of the glue involved in the fatal case. Exposures in these cases are much greater than would normally arise from occupational use of toluene. Thus Knox and Nelson¹² described an instance of permanent encephalopathy involving a man who inhaled toluene regularly for over 14 years.

Von Oettingen and co-workers⁴ found that human subjects exposed at 200 ppm suffered slight but definite changes in muscular coordination. They concluded that such concentrations were unlikely to have any discernible untoward effects on health. Gerarde⁹ however, believed that von Oettingen's work did not justify the 200 ppm limit. Ogata *et al*¹³ found that experimental human subjects exposed at 200 ppm for seven hours showed prolongation of reaction time, decrease in pulse rate and in systolic blood pressure. They consider 200 ppm too high as the MAC. Takeuchi¹⁴ exposed rats at 200 ppm and higher concentrations of toluene for 32 weeks and then to benzene for 39 days. On the basis of differences found between the toluene-exposed animals and controls, e.g. changes in weight of adrenal glands, he suggested that the MAC 200 ppm for toluene should be reconsidered.

Smyth *et al* reported an oral LD₅₀ administered to rats, to be 7.53 mL/kg.¹⁵

On the basis of the above data, a reduction in the TLV for toluene from 200 ppm to 100 ppm is recommended, with a STEL of 150 ppm.

Other recommendations: Cook (1945) 200 ppm; Smyth (1956) comments that this limit may permit early signs of narcosis; Jikins (1959) 200 ppm; ANSI (1967) 200 ppm; USSR (1967) 14 ppm; Czechoslovakia (1969) 50 ppm; West Germany (1974) 200 ppm; Sweden (1975) 100 ppm; East Germany (1973) 50 ppm; NIOSH (1973) 100 ppm.

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methylen chloride continued after exposure ceased. This solvent-induced COHb is apparently added to the body burden of carbon monoxide derived from other sources.

This study corroborated previous single exposure studies in that no deleterious effects upon the health or performance of healthy adults could be detected when they were repeatedly exposed to 250 ppm or less for 7.5 hours per day, five days per week for 2 weeks, or in the case of the male subjects, to 300 ppm on two consecutive days. Among the parameters studied were complete blood count, clinical chemistry (SMA 12), EKG, serum triglycerides, blood pressure, subjective signs and symptoms, urinary urobilinogen, urinary uroporphyrin, neurological tests, EEG, visual evoked response, pulmonary function and cognitive alertness, time estimation, coordination, arithmetic and inspection tests.

The increase in COHb was related to the magnitude of the vapor exposure. Both duration of exposure and vapor concentration were factors. Seven and one-half hour exposures to concentrations as low as 100 ppm for 5 days resulted in COHb elevations about 5 percent in nonsmokers. The odor was not objectionable at 250 ppm and many subjects could not detect it at 50 or 100 ppm.

Since the toxic effects of methylene chloride are due in part to its conversion to carbon monoxide, they would presumably be augmented by the presence of carbon monoxide in the air. Ponder *et al.*¹³ found the effects of CO and the COHb from methylene chloride to be additive in 3-hour exposure tests with rats. Therefore, whenever there is a combined exposure to the vapors of methylene chloride and carbon monoxide, the appropriate equation for mixtures should be used in determining whether or not the exposure is acceptable.

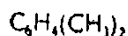
A time-weighted average TLV of 100 ppm is recommended for methylene chloride in the absence of occupational exposure to carbon monoxide. This recommendation is based upon experimental data obtained from non-smoking males at rest, and should keep COHb levels well below 5 percent. A STEL of 300 ppm is recommended since data indicate that neither undesirable CNS responses nor COHb values are likely to occur with such exposures to methylene chloride.^{14,15,16} Concurrent exposure to other source of carbon monoxide or physical activity will require assessment of the overall exposure and adjustment for the combined effect.

Other recommendations: NIOSH (1976) 75 ppm; West Germany (1979) and Elkins (1959) 200 ppm; ANSI (1969) 500 ppm; USSR (1970) 15 ppm; East Germany (1973), Romania (1975), Yugoslavia (1971) and Czechoslovakia (1976) 140 ppm; Sweden (1974) 100 ppm; others 200 or 250 ppm.

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XYLENE



o-, m-, p-isomers

TLV, 100 ppm (\approx 435 mg/m³)

STEL, 150 ppm (\approx 655 mg/m³)

Xylene is a clear, flammable liquid with an aromatic hydrocarbon odor and a molecular weight of 106.16. Commercial xylene is a mixture of three isomers, ortho, meta and para, with the meta form usually the principal component. According to Gerarde,⁽¹⁾ 6 to 15% of ethyl benzene may also be present. The physicochemical properties of the three isomers, meta, ortho, para, respectively, are: specific gravity, 0.8684, 0.8801 and 0.86104; boiling point, 138.8, 144 and 138.5° C; melting point, -47.4, -25 and -13 to -14° C. The vapor pressure at 25° C is between 7 and 9 mm Hg. The boiling ranges and flash points of the commercial product depends on its grade; the 10% grade boils between 135 and 145° C; closed cup flash points are from 81 to over 100° F. Xylene is insoluble in water, but miscible with absolute alcohol, ether and other organic solvents.

Xylene is present in gasoline and many petroleum solvents. It is used extensively as a solvent in paints and other coatings, especially the alkyl resin type, and in rubber cements. Meta-xylene is an intermediate in the preparation of isophthalic acid; ortho-xylene in the manufacture of phthalic anhydride; para-xylene in the synthesis of terephthalic acid. All isomers are used in making drugs, dyes and insecticides.

Fairhall⁽²⁾ considered the effects of xylene similar to those of toluene, but Gerarde⁽¹⁾ stated that the acute toxicity of the xylenes was higher.

Fabre and Truhaut⁽⁴⁾ exposed rats and rabbits to a mixture of xylene isomers at a concentration of about 690 ppm for eight hours a day, six days a week. After 130 days no significant deviations from normal in the peripheral blood were found. A decrease in red and white cell counts and an increase in the platelet count in the blood of rabbits followed similar exposures at 1150 ppm for 55 days. Reversible lesions in the cornea of cats exposed to xylene were observed.

Gerarde⁽¹⁾ listed headache, fatigue, lassitude, irritability and gastrointestinal disturbances such as nausea, anorexia and flatulence as the most frequent symptoms among workers exposed to xylene. A report which suggested that xylene might affect the heart and vascular system was cited.

Browning⁽⁵⁾ also recorded reports of gastrointestinal as well as neurological disturbances, and injury to heart, liver, kidneys and the nervous system among workers with xylene exposure. In addition, she noted a number of reports of blood dyscrasias, some of them fatal, associated with exposure to xylene. De Oliveira⁽⁶⁾ described the death from aplastic anemia of a lithographer who used xylene for several years; and Goldie⁽⁷⁾ reported a patient who had an

apparent epileptiform seizure following relatively brief exposure to xylene vapor.

Gerarde,⁽¹⁾ however, considered that industrial experience confirmed the animal experimentation evidence that xylene is not a myelotoxicant. Goldwater⁽⁸⁾ was of the opinion that xylene was probably less toxic than toluene to the bone marrow. In most of the cases of blood disease associated with xylene, the presence of benzene as an impurity was not ruled out.

Nelson and associates⁽⁹⁾ found 200 ppm of xylene definitely irritating to the eyes, nose and throat of experimental human subjects. Greenburg and Moskowitz⁽¹⁰⁾ suggested a maximum allowable concentration of 200 ppm. Cook,⁽¹¹⁾ Smyth,⁽¹²⁾ Elkins⁽¹³⁾ and Gerarde⁽¹⁾ all considered this value too high, and Gerarde suggested 600 ppm as a more acceptable limit.

The NIOSH criteria document on xylene, published in 1975,⁽¹⁴⁾ refers to a report by Morley et al.⁽¹⁵⁾ in which renal impairment and some evidence of disturbance of liver function were noted in three workers who were overcome by a gross overexposure to xylene (estimated concentration, 10,000 ppm); one worker died, the others suffered from amnesia and did recover, slowly however. A paper by Matthaus describes corneal changes in furniture polishers exposed to xylene in unknown concentrations.⁽¹⁶⁾

In a study of various hydrocarbon solvents, Carpenter et al.⁽¹⁷⁾ found the 4-hour LC₅₀ for rats to be 6700 ppm. The no-ill-effect concentration for rats and dogs, following 63 days (6 hours/day, 5 days/week) was 800 ppm. Sensory response experiments with human subjects indicated a hygienic standard of around 200 ppm.

The TLV of 100 ppm, first adopted in 1967, is retained with a STEL of 150 ppm. It is believed that irritant effect will be minimal, and that no significant degree of narcosis or chronic injuries will result from continued occupational exposure at that level.

NIOSH⁽¹⁴⁾ also recommended a workplace environmental standard of 100 ppm, as a TWA, with a ten minute ceiling of 200 ppm.

Other recommendations: ANSI (1970) 100 ppm; West Germany (1974) 200 ppm; Sweden (1975) 100 ppm; Czechoslovakia (1969) and East Germany (1973) 45 ppm; USSR (1972) 11 ppm.

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TRICHLOROACETIC ACID

TCA

CCl_3COOH

TLV, 1 ppm ($\approx 5 \text{ mg/m}^3$)

TCA forms deliquescent crystals with a molecular weight of 163.40 and a specific gravity of 1.6298. It is a relatively strong acid, which melts at 5°C , boils at 197.5°C and is nonflammable. TCA is soluble in water, alcohol and ether.

It is used in medicine, pharmacy, as a reagent for albumin detection and in making herbicides.

Trichloroacetic acid was first placed on the Notice of Intended Change in 1978 at 1 mg/m³. This value had been carried for 1979 and transferred to the adoption list in 1980. This value was in error. The TLV 0.75 ppm ($\approx 5 \text{ mg/m}^3$), which appeared on page 476 of the 1978 Supplemental Documentation v, was the value initially given TCA, and was to have been rounded off to 1 ppm, by analogy with 2,2-dichloropropionic acid (TLV 1 ppm). The numeral one was then inadvertently placed in the mg/m³ column in-

stead of the ppm column, and this error was not discovered until now. The correct adopted TLV is 1 ppm ($\approx 5 \text{ mg/m}^3$) and this correction will be made in the second printing of the 1980 TLV booklet. The following documentation reflects this value.

The oral LD₅₀ has been reported as 3.3 g/kg for rats,⁽¹⁾ for mice, 3.64 g/kg.⁽²⁾ By intraperitoneal administration, 500 mg/kg was fatal to mice.⁽³⁾

TCA is corrosive to the skin and eye, but not readily absorbed through the skin. Medical reports of acute exposure effects showed mild to moderate skin and eye burns.

A time-weighted TLV of 1 ppm is suggested, based largely on analogy to 2,2-dichloropropionic acid, and the above meager data.

Other recommendations: USSR (1976) 0.75 ppm

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1,2,4-TRICHLOROBENZENE

$\text{C}_6\text{H}_3\text{Cl}_3$

CEILING LIMIT, 5 ppm ($\approx 40 \text{ mg/m}^3$)

A colorless, stable liquid at room temperature, with an odor similar to that of o-dichlorobenzene. 1,2,4-trichlorobenzene has a molecular weight of 181.46 and a specific gravity of 1.4634 at 25°C . It melts at 1°C , boils at 213°C and has a reported flash point of 224.6°F . It is combustible and soluble in most organic solvents, but insoluble in water.

It is used as a dielectric fluid, heat transfer medium, in lubricants, insecticides and organic synthesis.

A study of the acute and subacute inhalation toxicity of trichlorobenzene (92% the 1,2,4-isomer) by Treon⁽¹⁾ indicated that the target organs from non-lethal exposures of rats, dogs, rats, rabbits and guinea pigs included the liver, kidney, ganglion cells at all brain levels, and mucous membranes. Local irritation of the lungs and functional changes in respiration, e.g., dyspnea, were noted in animals later dying from inhalation exposure.

Brown *et al.*⁽²⁾ reported 1,2,4-trichlorobenzene to have a single dose acute oral LD₅₀ of 756 mg/kg for rats and 766 mg/kg for mice. The acute percutaneous LD₅₀ for rats was 6139 mg/kg. Sublethal doses administered repeatedly to guinea pigs caused liver damage. Acute and short term (15 x 6 exposures, 70-200 ppm) inhalation studies failed to kill animals, and produced lethargy and retarded weight gain with no organ pathology.⁽³⁾ Cameron *et al.*⁽⁴⁾ reported that the trichlorobenzenes are less toxic to rats than the mono- and dichlorobenzenes.

The aforementioned studies are short term ones and information needed to recommend an airborne concentra-

tion to which workers may be repeatedly exposed during a working lifetime without adverse effects is limited. Cutaneous exposure to 1,2,4-trichlorobenzene does not cause chloracne or acneiform dermatitis but can cause dermal irritation which is probably attributable to its degreasing action.⁽⁵⁾ Industrial data report an odor threshold of approximately 3 ppm and minimal eye and throat irritation at 3-5 ppm in certain people.⁽⁶⁾ Twenty male rats, 4 rabbits and 2 male dogs were exposed at either 30 or 100 ppm 1,2,4-trichlorobenzene (98.4% purity, 1.4% 1,2,3-trichlorobenzene) 7 hours/day, 5 days/week for 30 exposures in 44 days. No adverse effects were detectable at 30 ppm with the exception of an elevation of urinary uroporphyrin and coproporphyrin in the rats only at 15 and 30 exposure days. No pathologic lesions could be attributed to the exposure in roughly 30 different specimens examined for each species.⁽⁷⁾ A second inhalation study was performed with 99.07% pure 1,2,4-trichlorobenzene 7 hours/day, 5 days/week for 26 consecutive weeks.⁽²⁾ Thirty rats, 16 rabbits, and 9 monkeys, all males, were exposed at zero, 25, 50 and 100 ppm. Pulmonary function and operant behavior in monkeys, ophthalmoscopic examination in rabbits and monkeys and body weight measurements, hematology and serum biochemical determinations in all species were conducted prior to and during the exposure period; no differences were noted among the four exposure groups. Microscopic changes were seen in the parenchymal cells of livers and kidneys from all groups of rats after 4 and 13 weeks of exposure to 1,2,4-TCB, but no exposure-related abnormalities were seen after 26 weeks of exposure in any of the three species understudy.

The above data do not indicate a high systemic toxicity. The recommended ceiling limit of 5 ppm, based on the irritating properties of TCB, seems low in comparison with

the limits for the dichlorobenzenes. For the present, this limit is retained.

Other recommendations for trichlorobenzene: Bulgaria, Poland, U.S.S.R., Yugoslavia, 1-4 ppm.

References:

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1,1,1-TRICHLOROETHANE

See: METHYL CHLOROFORM

1,1,2-TRICHLOROETHANE

Vinyl trichloride



Skin

TLV, 10 ppm ($\approx 45 \text{ mg/m}^3$)

STEL, 20 ppm ($\approx 90 \text{ mg/m}^3$)

A colorless, non-flammable liquid with a sweet odor. 1,1,2-trichloroethane has a molecular weight of 133.42 and a specific gravity of 1.4416 at 20°C. It boils at 113.7°C, freezes at -36.4°C and has a vapor pressure of 19 mm Hg at 20°C. Insoluble in water, it is miscible with alcohol, ether and other organic solvents.

It is used as a solvent for fats, resins, etc., and in organic synthesis.

1,1,2-trichloroethane depresses the central nervous system causing narcosis, in which respect it is considerably more potent than chloroform.⁽¹⁾ By inhalation its acute toxicity is somewhat greater for certain laboratory animals (cats) than that of chloroform. Narcotic concentrations of 1,1,2-trichloroethane result in irritation to the eyes and nose and injection of the conjunctiva. Death occurs from respiratory arrest. Concentrations producing deep narcosis and death are of the order of 13,600 ppm for a two-hour exposure. The corresponding concentration for chloroform is 30,000 to 40,000 ppm. 1,1,2-trichloroethane is lethal by oral and subcutaneous administration; 0.75 g/kg was lethal to dogs by mouth, compared with 2.25 g/kg for chloro-

form.⁽²⁾ Fatty degeneration of the liver was observed in dogs dying two or more days following administration of trichloroethane, which is also absorbed through the intact skin.⁽⁴⁾

More recent data include the following:⁽³⁾ oral LD_{50} , rat - 1140 mg/kg, intraperitoneal LD_{50} , mouse - 994, dog - 450 mg/kg; subcutaneous LD_{50} , mouse - 227 mg/kg. Exposure at 500 ppm for 8 hours was fatal to rats.

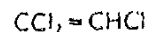
The current TLV of 10 ppm was based on the toxicological resemblance to symmetric tetrachloroethane, and by analogy with the TLV for chloroform, which at that time was 50 ppm. In view of the above comparisons of the toxicity of 1,1,2-trichloroethane with that of chloroform, a limit somewhat lower than 10 ppm, the TLV for the latter compound, might be in order for 1,1,2-trichloroethane. For the present, the TLV of 10 ppm and STEL of 20 ppm are retained.

Other recommendations: Several western European nations and Japan had adopted the 10 ppm TLV, as of 1977. Poland, with 22 ppm, was the only exception. West Germany (1979) considers it a potential carcinogen.

References:

1. Lazarew, N.W.: *Arch. Exptl. Path. Pharmacol.* 14:19 (1929).
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TRICHLOROETHYLENE



TLV, 50 ppm ($\approx 270 \text{ mg/m}^3$)

STEL, 150 ppm ($\approx 805 \text{ mg/m}^3$)

Trichloroethylene is a nonflammable, colorless liquid of sweetish odor. It has a molecular weight of 131.4 and a specific gravity of 1.4649. The boiling point is 87°C and solidifies at -84.8°C. The vapor pressure at 20°C equals 58 mm Hg. It is practically insoluble in water, but highly solu-

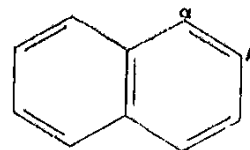
ble in lipids. (Partition coefficient at 37°C: blood-air 9, oil-air 943). In the presence of oxygen and short ultraviolet wavelength, trichloroethylene is decomposed to phosgene and hydrochloric acid.

Trichloroethylene is used for degreasing, dry cleaning, and as a solvent. In the past, trichloroethylene was used as an extractant in food-processing (FDA had approved residue below 25 ppm in decaffeinated ground coffee and 10 ppm for instant coffee). This was discontinued in 1975, when NCI issued an alert, warning that trichloroethylene may be a carcinogen. Its use as an anesthetic was aban-

NAPHTHA

See. RUBBER SOLVENT

NAPHTHALENE

 $C_{10}H_8$ TLV, 10 ppm (≈ 50 mg/m³)STEL, 15 ppm (≈ 75 mg/m³)

Naphthalene occurs commonly as white, crystalline flakes which have a strong coal tar odor. It has a molecular weight of 128.16 and a specific gravity of 1.145. It melts at 80.2° C, boils at 217.96° C and has a vapor pressure at 25° C of approximately 0.087 mm Hg. The open cup flash point is 176° F and closed cup is 190° F. Insoluble in water, it dissolves in most organic solvents.

Crystalline naphthalene finds household use as a moth repellent, scientific use in scintillation counters. It is an important raw material for the manufacture of phthalic anhydride, naphthol, hydrogenated naphthalenes and halogenated naphthalenes; it or its derivatives are employed in dyes, explosives, lubricants, tanning agents and emulsion breakers.

According to Flury and Zernik⁽¹⁾ and Patty,⁽²⁾ the inhalation of naphthalene vapor may cause headache, loss of appetite and nausea. Optical neuritis and injuries to the cornea and, in addition, kidney damage have also been reported. Ghetti and Mariani⁽³⁾ reported opacities of the lens in 8 of 21 workers who had been exposed to naphthalene for about five years. Ingestion of naphthalene in relatively large amounts has reportedly caused severe hemolytic anemia and hemoglobinuria.⁽⁴⁾ A hypersusceptibility, probably genetically based, is recognized.⁽⁵⁾

The oral LD₅₀ for rats is 1760 mg/kg.⁽⁶⁾ It was used as an anthelmintic for many years at dose levels, for adults, of 0.1 to 0.5 gram three times a day,⁽⁷⁾ several times higher than the lowest reported lethal dose for man of 50 mg/kg.⁽⁸⁾ An incident in which blankets containing naphthalene caused acute hemolytic effects in infants, in some cases fatal, has been described.⁽⁹⁾

Patty suggested 25 ppm as a tentative limit for naphthalene vapor in air. He noted that this corresponds to a saturation pressure of approximately 25% at 25° C. This value has been used at the Los Alamos Laboratories, according to

Hyatt and Milligan.⁽¹⁰⁾ Robbins,⁽¹⁰⁾ however, reported that concentrations in excess of about 15 ppm resulted in noticeable irritation of the eyes.

Gerarde⁽¹¹⁾ also suggested 25 ppm as a tentative limit, noting that it represents 25% of the concentration of naphthalene vapor in air saturated at 25° C.

In view of the fact that irritation is experienced at 15 ppm and that continued exposure may result in fairly serious eye effects, a limit lower than 25 ppm would seem in order. The value of 10 ppm TLV and 15 ppm STEL are recommended to prevent ocular effects, but possibly not blood changes in hypersusceptibles.

Other recommendations: West Germany, 10 ppm. East Germany and USSR, 4 ppm.

References:

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The TLV of 0.5 mg/m³ is believed low enough to minimize the incidence of chloracne and prevent serious injury to the liver. However, in view of the fact that hepatic changes in rats resulted from 143 eight-hour exposures at 1.44 mg/m³ of a mixture of penta- and hexachloronaphthalenes,⁽¹⁾ the margin of safety of the 0.5 mg/m³ limit for pentachloronaphthalene may be rather small. At this time, a STEL of 2 mg/m³ is suggested.

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PENTACHLOROPHENOL

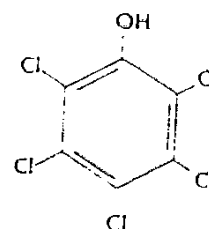
PCP; Chem-Yol; Permicide; Penta; Santophen 20; Dowicide 7

C₆HCl₅O

Skin

TLV, 0.5 mg/m³

STEL, 1.5 mg/m³



001033

Pentachlorophenol is a colorless, noncombustible solid with a phenolic odor and a pungent taste. The molecular weight is 266.35, specific gravity is 1.978 at 20° C and, at the same temperature, the reported vapor pressure of 0.00017 mm Hg. It is volatile with steam and noncorrosive to metals. Its melting point is 190° C with a boiling point of 310° C. The compound is soluble in water to the extent of 14 ppm at 20° C. Its solubility in organic solvents depends greatly on the nature of the solvent. Barely soluble in alkanes, pentachlorophenol is most soluble in methyl alcohol.

It is a contact herbicide, fungicide, wood preservative and molluscicide.

The most important effect of PCP inhalation is acute poisoning centering in the circulatory system with accompanying heart failure. Kehoe *et al.*⁽¹⁾ found no evidence of chronic poisoning in rabbits. The smallest lethal intravenous dose was 22 mg/kg. The compound penetrates the skin readily. Physiologic injury is mainly vascular with heart failure. Industrial hygiene experience shows that PCP and its sodium salt are capable of inducing discomfort and local as well as systemic effects. Dusts are particularly irritating to the eyes and nose in concentrations greater than 1 mg/m³.⁽²⁾ Some irritation of the nose may occur at 0.3 mg/m³.⁽³⁾ Hardened workers can tolerate up to 2.4 mg/m³.⁽⁴⁾ PCP is highly poisonous with a wide range of acute action but no pronounced cumulative properties. It has been demonstrated⁽⁵⁾ that dermal penetration is the most dangerous pathway of PCP exposure. The acute gastric LD₅₀'s for mice and rats are 130 and 184 mg/kg, respectively.⁽⁶⁾ The dermal LD₅₀ in rats is 96 mg/kg. The inna-

lation LD₅₀ for rats is 335 mg/m³ and for mice 225 mg/m³.⁽¹⁾ The rat embryo was shown to be most susceptible to the toxic effects of PCP during the early phases of organogenesis.⁽⁴⁾ The world literature reveals about 51 cases of PCP poisoning from its use as a herbicide, molluscicide or wood preservative of which 30 out of 51 resulted in death.⁽⁷⁾ The survivors of PCP intoxication suffer with impairments in autonomic function, circulation, visual damage and an acute type of scotoma.⁽⁸⁾ Other damage included acute inflammation of the conjunctiva and characteristically shaped corneal opacity, corneal numbness and slight mydriasis.⁽⁹⁾ Other symptoms involve excessive sweating, tachycardia, tachypnea, respiratory distress, hepatic enlargement and metabolic acidosis.

The 0.5 mg/m³ TLV and the STEL of 1.5 mg/m³ are derived by analogy with other compounds of similar action and toxicity in addition to the specific available information. They are believed low enough to prevent vascular injury.

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3. Demidenko, N.M.: *Gigiena Truda i Prot. Zabolevaniya* 13(9) 58 (1969).
4. Schwetz, B.A., Gehring, P.J.: *Tox. Appl. Pharm.* 24(3) 455 (1973).
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PHENOL

C_6H_5OH

Skin

TLV, 5 ppm ($\approx 19 \text{ mg/m}^3$)

STEL, 10 ppm ($\approx 38 \text{ mg/m}^3$)



Pure phenol is a solid at room temperature and is liquified by mixing with about 8% water. The molecular weight is 94.11 and the specific gravity is 1.07. It is white but often has a pinkish hue resulting from impurities or exposure to light and has a characteristic sweet, tarry odor. The solid has a boiling point of 182°C and, when free from water and cresols, it congeals at 41°C and melts at 43°C . At 25°C it has a vapor pressure of 0.35 mm Hg. It is soluble in water and most organic solvents and is combustible, having a closed cup flash point of 172°F .

Its chief use is as a starting point in the manufacture of phenolic resins, bis-phenol-A, caprolactam and many other chemicals and drugs. It is employed as a disinfectant, in germicidal paints and as a fumicide.

Deichmann¹ reported results of animal experimentation in which guinea pigs were severely injured by inhalation for 21 days of phenol vapor at concentrations of from 25 to 50 ppm. Post mortem evidence of acute toxicity to the lungs, heart, liver and kidney was found.

Intermittent industrial exposures (five to ten minutes per hour) inside a conditioning room for phenol-impregnated asbestos resulted in marked irritation of the nose, throat and eyes. The average phenol concentration in the room was 46 ppm, although formaldehyde (18 ppm) also was found. Urine sulfate ratios were 79.4 and 86.7 percent. Workers at the same plant, continuously exposed during winding operations, experienced no respiratory irritation although the odor of phenol was noticeable. The average concentration in the room was 4 ppm. Urine sulfate ratios averaged 74 percent.

Due in part to its low volatility, phenol does not frequently constitute a serious respiratory hazard in industry. Formerly its use as an antiseptic in surgery resulted in numerous cases of sub-acute or chronic poisoning among surgeons and their assistants.¹⁴ Urinary excretions of 2 grams per day, by patients, have been reported.¹⁵ Absorption of 2 grams of phenol could result from eight hours inhalation at about 50 ppm.

According to Thomas and Back¹⁶ the TLV of 5 ppm provides a sufficiently large factor of safety to prevent systemic poisoning if skin absorption is avoided.

In 1976 NIOSH published a criteria document in which the toxicology of phenol was reviewed. The serious local and systemic effects of contact of the skin with phenol and its concentrated solutions were properly emphasized. Relatively little additional information on the effects of inhalation, bearing on the TLV, however, turned up. A report by Petrov¹⁷ of poisonings among workers in Russia, who quenched coke with waste water containing 0.3 to 0.8 g of phenol per liter is discussed. Air samples indicated phenol vapor concentrations of the order of 2 to 3 ppm and the author believed that phenol might have been implicated in the intoxications, which were not described.

The NIOSH recommendation of 20 mg/m³ as a time-weighted average standard is essentially the same as the TLV of 5 ppm established in 1952. The NIOSH ceiling of 100 mg/m³ for any 15 minute period is higher than the STEL of 38 mg/m³ or 10 ppm.

Except for the USSR, which has set an MAC of 1.5 ppm, most of the published hygienic standards (East and West Germany, Sweden, Czechoslovakia) are either 14 or 20 mg/m³ or for practical purposes 5 ppm.

References

1. Deichmann, W.B., Kitzmiller, K.V., Witherup, S.: *Am. J. Clin. Path.* 40:3, 1964.
2. Connecticut Bur. of Ind. Hygiene: Unpublished data.
3. Elkins, H.B.: *The Chemistry of Industrial Toxicology*, 2nd ed., John Wiley & Sons, N.Y. (1955).
4. Patty, F.A.: *Industrial Hygiene & Toxicology*, 2nd ed., Vol. 2, 1971, Interscience, N.Y. (1963).
5. Thomas, A.A., Back, K.C.: A Symposium on Toxicity in the Closed Ecological System, p. 135. Penma & Crosby Ed., Lockheed Missiles & Space Co., Palo Alto, CA (1964).
6. NIOSH: *Criteria for a Recommended Standard-Occupational Exposure to Phenol*, HEW Publication No. (NIOSH) 76-196 (1976).
7. Petrov, V.I.: Cases of Phenol Vapor Poisoning During Coke Slaking with Phenol Water, in Levine, B.S. (trans): *USSR Literature on Air Pollution and Related Occupational Diseases-A Survey*, U.S. Dept. of Commerce, National Technical Information Service 8-219 (1963) (NTIS 63-11570), Springfield, VA. Cited by NIOSH in ref. 6.

<h3 style="text-align: center;">6. FIRE HAZARDS</h3> <p>51 Flash Point: $> 40^{\circ}\text{F}/10^{\circ}\text{C}$</p> <p>52 Flammability Limits in Air: Not pertinent</p> <p>63 Fire Extinguishing Agents: Dry chemical, carbon dioxide or foam</p> <p>54 Fire Extinguishing Agents Not to be Used: Water may be ineffective</p> <p>45 Special Hazards of Combustion Products: Data not available</p> <p>66 Behavior in Fire: Heavy irritating black smoke is formed</p> <p>67 Ignition Temperature: $> 37^{\circ}\text{F}$</p> <p>68 Electrical Hazards: Not pertinent</p> <p>69 Burning Rate: Data not available</p>	<h3 style="text-align: center;">8. WATER POLLUTION</h3> <p>81 Aquatic Toxicity: Data not available</p> <p>52 Waterborne Toxicity: Data not available</p> <p>83 Biological Oxygen Demand (BOD): Data not available</p> <p>84 Food Chain Concentration Potentials: None</p>																																				
<h3 style="text-align: center;">7. CHEMICAL REACTIVITY</h3> <p>71 Reactivity with Water: No react. on</p> <p>72 Reactivity with Common Materials: no reaction</p> <p>73 Stability During Transport: Stable</p> <p>74 Neutralizing Agents for Acids and Bases: Not pertinent</p> <p>75 Polymerization: Not pertinent</p> <p>76 Inhibitor of Polymerization: Not pertinent</p>	<h3 style="text-align: center;">9. SELECTED MANUFACTURERS</h3> <p>1. Union Carbide Corporation Pamcor Division 375 Park Avenue New York, N.Y. 10017</p> <p>2. Rogers Company Inc. Organic Materials Division Edgemoor Building Pittsburgh, Pa. 15206</p> <p>3. Allied Chemical Corp., Division Specialty Sales Division Innovation Park Plaza 1330 South Teles Street Innovation, Ohio 44138</p>																																				
<h3 style="text-align: center;">11. HAZARD ASSESSMENT CODE</h3> <p style="font-size: small;">See Hazard Assessment Manual, 13 and 14</p> <p style="text-align: center;">A-F, C, X-Y</p>	<h3 style="text-align: center;">10. SHIPPING INFORMATION</h3> <p>101 Grade or Purity: No grade or purity restrictions depending on shipping. All have their properties.</p> <p>102 Storage Temperature: Ambient</p> <p>103 Inert Atmosphere: No requirements</p> <p>104 Venting: Special considerations</p>																																				
<h3 style="text-align: center;">12. HAZARD CLASSIFICATIONS</h3> <p>12.1 Code of Federal Regulations: Combustible Liquid</p> <p>12.2 NFPA Hazard Rating for Bulk Water Transportation:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Category</th> <th>Rating</th> </tr> </thead> <tbody> <tr> <td>Fire</td> <td>1</td> </tr> <tr> <td>Health</td> <td></td> </tr> <tr> <td>Vapor Irritant</td> <td>2</td> </tr> <tr> <td>Liquid or Solid Irritant</td> <td>3</td> </tr> <tr> <td>Poison</td> <td>2</td> </tr> <tr> <td>Water Pollution</td> <td></td> </tr> <tr> <td>Human Toxicity</td> <td>2</td> </tr> <tr> <td>Aquatic Toxicity</td> <td>3</td> </tr> <tr> <td>Aesthetic Effect</td> <td>4</td> </tr> <tr> <td>Reactivity</td> <td></td> </tr> <tr> <td>Other Chemicals</td> <td>1</td> </tr> <tr> <td>Water</td> <td>0</td> </tr> <tr> <td>Self Reaction</td> <td>0</td> </tr> </tbody> </table> <p>12.3 NFPA Hazard Classifications:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Category</th> <th>Classification</th> </tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td> <td>2</td> </tr> <tr> <td>Flammability (Red)</td> <td>2</td> </tr> <tr> <td>Reactivity (Yellow)</td> <td>0</td> </tr> </tbody> </table>	Category	Rating	Fire	1	Health		Vapor Irritant	2	Liquid or Solid Irritant	3	Poison	2	Water Pollution		Human Toxicity	2	Aquatic Toxicity	3	Aesthetic Effect	4	Reactivity		Other Chemicals	1	Water	0	Self Reaction	0	Category	Classification	Health Hazard (Blue)	2	Flammability (Red)	2	Reactivity (Yellow)	0	<h3 style="text-align: center;">13. PHYSICAL AND CHEMICAL PROPERTIES</h3> <p>13.1 Physical State at 15°C and 1 atm.: liquid</p> <p>13.2 Molecular Weight: 164.0</p> <p>13.3 Boiling Point at 1 atm.: $> 316^{\circ}\text{F}$ or $> 160^{\circ}\text{C}$ or $> 313^{\circ}\text{K}$</p> <p>13.4 Freezing Point: Not pertinent</p> <p>13.5 Critical Temperature: Not pertinent</p> <p>13.6 Critical Pressure: Not pertinent</p> <p>13.7 Specific Gravity: 0.9109 at 15°C (liquid)</p> <p>13.8 Liquid Surface Tension: (at 15 degrees) $= 0.015 \text{ N/m at } 20^{\circ}\text{C}$</p> <p>13.9 Liquid-Water Interfacial Tension: (at 15 degrees) $= 0.020 \text{ N/m at } 20^{\circ}\text{C}$</p> <p>13.10 Vapor (Gas) Specific Gravity: Not pertinent</p> <p>13.11 Rate of Specific Heat of Vapor (Gas): Not pertinent</p> <p>13.12 Latent Heat of Vaporization: Not pertinent</p> <p>13.13 Heat of Combustion: (at 15 degrees) $= 4.43 \text{ cal/g} = 18.5 \times 10^3 \text{ J/kg}$</p> <p>13.14 Heat of Decomposition: Not pertinent</p> <p>13.15 Heat of Solution: Not pertinent</p> <p>13.16 Heat of Polymerization: Not pertinent</p>
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Continued on pages 7 and 8

NOTES

001036

Occupational Health Guideline for Phenol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: C_6H_5OH
- Synonyms: Carbolic acid; monohydroxybenzene
- Appearance and odor: Colorless to pink solid or thick liquid with a characteristic, sweet, tarry odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for phenol is 5 parts of phenol per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 19 milligrams of phenol per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 20 mg/m^3 averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 60 mg/m^3 averaged over a 15-minute period. The NIOSH Criteria Document for Phenol should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

• Routes of exposure

Phenol can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. It may enter the body through the skin.

• Effects of overexposure

1. Short-term Exposure: Phenol has a marked corrosive effect on any tissue. When it comes in contact with the eyes, it may cause severe damage and blindness. On contact with the skin, it does not cause pain but causes a whitening of the exposed area. If the chemical is not removed promptly, it may cause a severe burn or

systemic poisoning. Systemic effects may occur from any route of exposure, especially after skin contact.

2. Long-term Exposure: Repeated or prolonged exposure to phenol may cause chronic phenol poisoning. The symptoms of chronic poisoning include vomiting, difficulty in swallowing, diarrhea, lack of appetite, headache, fainting, dizziness, dark urine, mental disturbances, and possibly a skin rash. Liver damage and discoloration of the skin may occur.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to phenol.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to phenol at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of convulsive disorders or abnormalities of the skin, respiratory tract, liver, or kidneys would be expected to be at increased risk from exposure. Examination of the liver, kidneys, and respiratory tract should be stressed. The skin should be examined for evidence of chronic disorders.

—Urinalysis: Darkening of the urine has occurred in persons exposed to phenol after accidental ingestion or skin contact. A urinalysis should be performed, including at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. Urinary phenol is useful if good individual background levels are available.

—Liver function tests: Since liver damage has been observed in humans exposed to phenol, a profile of liver function should be performed by using a medically acceptable array of biochemical tests.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

2. **Periodic Medical Examination:** The aforementioned medical examinations should be repeated on an annual basis.

• **Summary of toxicology**

Phenol in the vapor form or in solution is an irritant to the eyes, mucous membranes, and skin; systemic absorption causes central nervous system effects as well as liver and kidney damage. Sudden collapse is characteristic of gross overexposure. In animals, prolonged inhalation of the vapor at 30 to 60 ppm induced respiratory difficulty, lung damage, and paralysis. Systemic absorption by animals caused muscle twitching and severe convulsions. There are no reports of human fatalities from inhalation of the vapor, although one case of severe poisoning has been reported. Ingestion of lethal amounts (as little as 1 g) cause severe burns of the mouth and throat, marked abdominal pain, cyanosis, muscular weakness, collapse, coma, and death; tremors, convulsions, or muscle twitching were occasionally observed but were not severe. A laboratory technician repeatedly exposed to unknown vapor concentrations and liquid spilled on the skin developed anorexia, weight loss, weakness, muscle aches and pain, and dark urine; during several months of nonexposure there was gradual improvement in his condition, but after brief reexposure he suffered an immediate worsening of symptoms with prompt darkening of the urine and tender enlargement of the liver. Brief intermittent industrial exposures to vapor concentrations of 48 ppm of phenol (accompanied by 8 ppm of formaldehyde) caused marked irritation of eyes, nose, and throat. Concentrated phenol solutions are severely irritating to the human eye and cause conjunctival swelling; the cornea becomes white and hypesthetic; loss of vision has occurred in some cases. Solutions of phenol have a marked corrosive action on any tissue on contact; on skin, there is local anesthesia and a white discoloration, and the area may subsequently become gangrenous; severe dermatitis will result from contact with dilute solutions, and prolonged exposure may result in ochronosis. In workers making phenol-formaldehyde plastic, the urinary level of total phenol, free plus conjugated, was proportional to the air concentration of phenol up to 12.5 mg/m³ of workroom air. Mice were treated twice weekly for 72 weeks by application of 1 drop of a 10% solution of phenol in benzene to the shaved dorsal skin; after 52 weeks of treatment there were papillomas in 5 of 14 mice, and 1 fibrosarcoma appeared at 58 weeks.

CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data**

1. Molecular weight: 94.11
2. Boiling point (760 mm Hg): 182 C (359 F)
3. Specific gravity (water = 1): 107 (solid); 1.05 (liquid)
4. Vapor density (air = 1 at boiling point of phenol): 3.24

2 Phenol

5. Melting point: 41 C (106 F)

6. Vapor pressure at 20 C (68 F): 0.36 mm Hg

7. Solubility in water, g/100 g water at 20 C (68 F): 8.4

8. Evaporation rate (butyl acetate = 1): Less than 0.01

• **Reactivity**

1. Conditions contributing to instability: Heat

2. Incompatibilities: Contact with strong oxidizers (especially calcium hypochlorite) may cause fires and explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving phenol.

4. Special precautions: Liquid phenol will attack some forms of plastics, rubber, and coatings. Hot liquid phenol will attack aluminum, magnesium, lead, and zinc metals.

• **Flammability**

1. Flash point: 79 C (174 F) (closed cup)

2. Autoignition temperature: 715 C (1319 F)

3. Flammable limits in air, % by volume: Lower: 1.7; Upper: 8.6

4. Extinguishant: Alcohol foam, carbon dioxide, dry chemical

• **Warning properties**

1. Odor Threshold: Summer reports that the odor threshold of phenol is 3 ppm; the Manufacturing Chemists Association reports 0.3 ppm; Thienes and Haley report 5 ppm.

2. Irritation Levels: The *Documentation of TLVs* reports that intermittent exposures to 48 ppm phenol have been observed to produce eye, nose, and throat irritation. Formaldehyde was also present in this atmosphere at a concentration of 8 ppm. The Respirator Review Committee considers the source of the eye irritation to be the 8 ppm formaldehyde rather than the phenol.

3. Evaluation of Warning Properties: Since the odor threshold of phenol is at or below the permissible exposure limit, phenol is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of phenol. Each measurement

should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of phenol in a bubbler containing sodium hydroxide, followed by treatment with sulfuric acid, and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure phenol may be used. An analytical method for phenol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 6, 1980, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00369-6).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with solid or liquid phenol or liquids containing phenol.
- If employees' clothing has had any possibility of being contaminated with solid or liquid phenol or liquids containing phenol, employees should change into uncontaminated clothing before leaving the work premises.
- Clothing which has had any possibility of being contaminated with solid or liquid phenol or liquids containing phenol should be placed in closed containers for storage until it can be discarded or until provision is

made for the removal of phenol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the phenol, the person performing the operation should be informed of phenol's hazardous properties.

- Where there is any possibility of exposure of an employee's body to solid or liquid phenol or liquids containing phenol, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.
- Non-impervious clothing which becomes contaminated with phenol should be removed immediately and not reworn until the phenol is removed from the clothing.
- Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of solid or liquid phenol or liquids containing phenol contacting the eyes.
- Where there is any possibility that employees' eyes may be exposed to solid or liquid phenol or liquids containing phenol, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes contaminated with phenol should be immediately washed or showered with soap or mild detergent and water to remove any phenol.
- Any clothing which becomes wet with liquid phenol or liquids containing phenol should be removed immediately and not reworn until the phenol is removed from the clothing.
- Eating and smoking should not be permitted in areas where solid or liquid phenol or liquids containing phenol are handled, processed, or stored.
- Employees who handle solid or liquid phenol or liquids containing phenol should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to phenol may occur and control methods which may be effective in each case:

Operation

Application and curing of bonding resin in plywood manufacture; application and curing of molding resins in manufacture of molded articles, such as

Controls

Process enclosure; local exhaust ventilation; personal protective equipment

electrical appliances, automotive parts, foundry sand molds, and utensil handles; manufacture of friction materials, bonded abrasives, coated abrasives, wood particle board, and insulation materials

Use in industrial coatings in drum and can linings, milk and beer-processing equipment, water tanks and air-conditioning equipment, decorative laminates, and textile coatings

Use in synthesis of thermosetting phenolic resins, epoxy, polycarbonate, phenoxy, and polysulfone; synthesis of aprotactam for use in nylon 6 fibers, plastics, and films

Use in synthesis of agricultural chemicals and intermediates; synthesis of pharmaceuticals, rubber and plastic plasticizers, antioxidants, curing agents, and intermediates

Use in synthesis of stabilizers and preservatives for dyes, perfumes, and fungicides

Use during solvent refining of lubrication oil and wax; use in synthesis of additives for gasoline and lubricating fluids and intermediates

Process enclosure; local exhaust ventilation; personal protective equipment

Process enclosure; local exhaust ventilation; personal protective equipment

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Use in synthesis of intermediates in polyester production; production of corrosion-resistant polyester and polyester polyols; use in synthesis of dye intermediates

Use in synthesis of surface-active agents and detergent intermediates; in synthesis of explosives

Use in manufacture of disinfectant agents and products for industrial and household use

Use in synthesis of synthetic cresols and xlenols

Process enclosure; local exhaust ventilation; personal protective equipment

Process enclosure; local exhaust ventilation; personal protective equipment

Process enclosure; local exhaust ventilation; personal protective equipment

Process enclosure; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If solid or liquid phenol or liquids containing phenol get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If solid or liquid phenol or liquids containing phenol get on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If solid or liquid phenol or liquids containing phenol penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Get medical attention immediately.

• Breathing

If a person breathes in large amounts of phenol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When solid or liquid phenol or liquids containing phenol have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

- **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

- If phenol is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill.
2. If in the solid form, for small quantities, sweep onto paper or other suitable material, place in an appropriate container and burn in a safe place (such as a fume hood). Large quantities may be reclaimed; however, if this is not practical, dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber.
3. If in the liquid form, for small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber.

- Waste disposal methods:

Phenol may be disposed of:

1. If in the solid form, by making packages of phenol in paper or other flammable material and burning in a suitable combustion chamber, or by dissolving phenol in a flammable solvent (such as alcohol) and atomizing in a suitable combustion chamber.
2. If in the liquid form, by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill, or by atomizing the liquid in a suitable combustion chamber.

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RESPIRATORY PROTECTION FOR PHENOL

Condition	Minimum Respiratory Protection* Required Above 5 ppm
Vapor or Particulate Concentration	
50 ppm or less	Any chemical cartridge respirator with an organic vapor cartridge(s) and dust and mist filter(s). Any supplied-air respirator. Any self-contained breathing apparatus.
100 ppm or less	A chemical cartridge respirator with a full facepiece, organic vapor cartridge(s), and dust and mist filter(s). A gas mask with a chin-style or a front- or back-mounted organic vapor canister and dust and mist filter. Any supplied air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 100 ppm** or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors and particulates. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

**Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of phenol; however, this equipment should be selected, used, and maintained under the immediate supervision of trained personnel. Where supplied-air suits are used above a concentration of 100 ppm, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.

Occupational Health Guideline for Pentachlorophenol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: C_5Cl_5OH
- Synonyms: PCP; penta
- Appearance and odor: Light brown solid with a pungent odor when hot.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for pentachlorophenol is 0.5 milligram of pentachlorophenol per cubic meter of air (mg/m^3) averaged over an eight-hour work shift.

HEALTH HAZARD INFORMATION

• Routes of exposure

Pentachlorophenol can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

• Effects of overexposure

Exposure to pentachlorophenol may cause irritation of the eyes and respiratory tract. Bronchitis has been reported to occur. Systemic effects from either a large exposure or repeated smaller exposures include weakness, loss of appetite, nausea, vomiting, shortness of breath, chest pain, excessive sweating, headache, and dizziness. In fatal cases the temperature is often very high and death may occur as early as three hours after the onset of symptoms. The risk of serious intoxication is greater in hot weather. Persons with decreased liver or kidney functions are more susceptible to poisoning from this chemical. Repeated exposure to pentachlorophenol may cause an acne-like skin rash and liver

damage. Commercial pentachlorophenol may be contaminated with dioxin compounds which are much more toxic than pentachlorophenol.

• Reporting signs and symptoms:

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to pentachlorophenol.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to pentachlorophenol at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination. The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the cardiovascular system, eyes, upper respiratory tract, liver, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders. Analysis of the urine for pentachlorophenol may be helpful in estimating the extent of absorption.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• Summary of toxicology

Pentachlorophenol dust and mist cause irritation of the eyes and upper respiratory tract; absorption results in an increase in metabolic rate and hyperpyrexia; prolonged skin exposure causes an acneiform dermatitis. Human exposure to dust or mist concentrations greater than $1 mg/m^3$ causes pain in the nose and throat, violent sneezing, and cough; $0.3 mg/m^3$ may cause some nose irritation; persons acclimated to pentachlorophenol can tolerate concentrations up to $2.4 mg/m^3$. Pentachlorophenol readily penetrates the skin; systemic intoxication is cumulative and has been fatal. Intoxication is characterized by weakness, anorexia, weight loss, and profuse sweating; there also may be headache, dizziness, nausea, vomiting, dyspnea, and chest pain. In fatal cases, the body temperature is frequently extremely high and

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

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death has occurred as early as 3 hours after the onset of symptoms. The risk of serious intoxication is increased during hot weather; persons with impaired liver or kidney function are more susceptible to the effects of pentachlorophenol. The dust, mist, and vapor cause eye irritation. Prolonged exposure of workers has caused an acneiform dermatitis; 10 workers engaged in production of pentachlorophenol for 5 to 10 months developed a widely disseminated skin eruption characterized by small and large furuncles, brown pigmentation, and some cicatrization; 7 workers also developed severe bronchitis; all but 1 worker still showed signs of extensive acne more than a year after cessation of exposure, and 4 still complained of bronchitis. On the skin, solutions of pentachlorophenol as dilute as 1% may cause irritation if contact is repeated or prolonged.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
 1. Molecular weight: 266.3
 2. Boiling point (760 mm Hg): 311 C (592 F) (decomposes)
 3. Specific gravity (water = 1): 2.0
 4. Vapor density (air = 1 at boiling point of pentachlorophenol): Not applicable
 5. Melting point: 182 – 190 C (360 – 374 F)
 6. Vapor pressure at 20 C (68 F): 0.00017 mm Hg
 7. Solubility in water, g/100 g water at 20 C (68 F): 0.002
 8. Evaporation rate (butyl acetate = 1): Not applicable
- **Reactivity**
 1. Conditions contributing to instability: None.
 2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
 3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, chlorinated phenols, and carbon monoxide) may be released when pentachlorophenol decomposes.
 4. Special precautions: None.
- **Flammability**
 1. Not combustible
- **Warning properties**
 1. Odor Threshold: The AIHA *Hygienic Guide* states that pentachlorophenol has a characteristic odor. No quantitative information is available, however, concerning the odor threshold of this substance.
 2. Irritation Levels: The *Documentation of TLVs* states that "dusts are particularly irritating to the eyes and nose, in concentrations appreciably greater than 1 mg/m³, but some irritation of the nose may occur at 0.3 mg/m³. Hardened workers can tolerate up to 2.4 mg/m³."
 3. Evaluation of Warning Properties: Through its irritant effects, pentachlorophenol can be detected within three times of the permissible exposure limit. For the purposes of this guideline, therefore, pentachlorophenol is treated as a material with good warning

properties.

MONITORING AND MEASUREMENT PROCEDURES

• General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Method

An analytical method for pentachlorophenol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 4, 1978, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-003 (78)).

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RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with pentachlorophenol or liquids containing pentachlorophenol.
- If employees' clothing has had any possibility of being contaminated with pentachlorophenol or liquids containing pentachlorophenol, employees should change into uncontaminated clothing before leaving the work premises.

- Clothing which has had any possibility of being contaminated with pentachlorophenol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of pentachlorophenol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the pentachlorophenol, the person performing the operation should be informed of pentachlorophenol's hazardous properties.

- Where there is any possibility of exposure of an employee's body to pentachlorophenol or liquids containing pentachlorophenol, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

- Non-impervious clothing which becomes contaminated with pentachlorophenol should be removed immediately and not reworn until the pentachlorophenol is removed from the clothing.

- Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of pentachlorophenol or liquids containing pentachlorophenol contacting the eyes.

- Where there is any possibility that employees' eyes may be exposed to pentachlorophenol or liquids containing pentachlorophenol, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes contaminated with pentachlorophenol should be immediately washed or showered with soap or mild detergent and water to remove any pentachlorophenol.

- Workers subject to skin contact with pentachlorophenol or liquids containing pentachlorophenol should wash with soap or mild detergent and water any areas of the body which may have contacted pentachlorophenol at the end of each work day.

- Eating and smoking should not be permitted in areas where pentachlorophenol or liquids containing pentachlorophenol are handled, processed, or stored.

- Employees who handle pentachlorophenol or liquids containing pentachlorophenol should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to pentachlorophenol may occur and control methods which may be effective in each case:

Operation

Formulation of preservatives, pesticides, and fungicides

Application as a preservative for wood, starch, paint, adhesives, leather, latex, and oils; use in slime-algae control; use as a pesticide, herbicide, and snail control agent

Manufacture of pentachlorophenol

Controls

Process enclosure; local exhaust ventilation; personal protective equipment

Personal protective equipment

Process enclosure; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If pentachlorophenol or liquids containing pentachlorophenol get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If pentachlorophenol or liquids containing pentachlorophenol get on the skin, immediately wash the contaminated skin using soap or mild detergent and water. If pentachlorophenol or liquids containing pentachlorophenol penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation is present after washing, get medical attention.

• Breathing

If a person breathes in large amounts of pentachlorophenol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When pentachlorophenol or liquids containing pentachlorophenol have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency

rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills until cleanup has been completed.

- If pentachlorophenol is spilled, the following steps should be taken:

1. Ventilate area of spill.

2. Collect spilled material in the most convenient and safe manner and deposit in sealed containers for reclamation or for disposal in a secured sanitary landfill. Liquid containing pentachlorophenol should be absorbed in vermiculite, dry sand, earth, or a similar material.

- Waste disposal method:

Pentachlorophenol may be disposed of in sealed containers in a secured sanitary landfill.

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RESPIRATORY PROTECTION FOR PENTACHLOROPHENOL

Condition	Minimum Respiratory Protection* Required Above 0.5 mg/m ³
Particulate or Vapor Concentration	
2.5 mg/m ³ or less	<p>Any chemical cartridge respirator with an organic vapor cartridge(s) and dust, fume, and mist filter(s), including pesticide respirators which meet the requirements of this class.**</p> <p>Any supplied-air respirator.**</p> <p>Any self-contained breathing apparatus.**</p>
25 mg/m ³ or less	<p>Any chemical cartridge respirator with a full facepiece, an organic vapor cartridge(s), and dust, fume, and mist filter(s), including pesticide respirators which meet the requirements of this class.</p> <p>A gas mask with a chin-style or a front- or back-mounted organic vapor canister and dust, fume, and mist filter, including pesticide respirators which meet the requirements of this class.</p> <p>Any supplied-air respirator with a full facepiece, helmet, or hood.</p> <p>Any self-contained breathing apparatus with a full facepiece.</p>

150 mg/m³ or less

**If eye irritation occurs, full-facepiece respiratory protective equipment should be used.